

Endangered Species Act
Section 7 Consultation

BIOLOGICAL OPINION

On the Impacts From the Collection, Rearing, and Release of Salmonids
Associated with Artificial Propagation Programs in the Upper Willamette
Spring Chinook and Winter
Steelhead Evolutionarily Significant Units

Action Agencies:

U.S. Army Corps. of Engineers
Bonneville Power Administration

Consultation Conducted by:

National Marine Fisheries Service,
Northwest Region

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1 Introduction

1.1 Consultation History

In March, 1999, the National Marine Fisheries Service (NMFS) listed spring chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*) in the Upper Willamette River Evolutionarily Significant Units (ESUs; Figure 1) as threatened under the Endangered Species Act (ESA; 64 FRN 14308; 64 FRN 14517). Critical habitat was designated for the Upper Willamette ESUs in February, 2000 (65 FRN 7764). On March 17, 1999, the first meeting was held with representatives from the U.S. Army Corps of Engineers (Corps), Oregon Department of Fish and Wildlife (ODFW), and NMFS to discuss artificial propagation programs potentially affecting listed chinook salmon and steelhead in the Willamette Basin (NMFS 1999a). In July, 1999, NMFS requested reinitiation of consultation for artificial propagation programs in the Columbia Basin in order to assess impacts of these actions on the recently listed ESUs (including Upper Willamette ESUs). In a letter dated March 29, 2000 (Corps 2000), the Corps requested re-initiation of section 7 consultation to address impacts from the operation of its artificial programs on listed Upper Willamette River ESUs. Related to the hatchery programs in the Willamette Basin, attached to the cover letter were Hatchery and Genetics Management Plans (HGMPs) for spring chinook at Clackamas Hatchery, Marion Forks Hatchery, South Santiam Hatchery, McKenzie Hatchery, and Willamette Hatchery. An HGMP was also submitted for the summer steelhead hatchery program and a biological assessment for the hatchery trout program at Leaburg Hatchery. The Corps concluded its hatchery programs would adversely affect listed winter steelhead and spring chinook but not jeopardize their continued existence.

1.2 Scope and Purpose of Biological Opinion

Federal agencies are required to consult under section 7(a)(2) of the ESA with NMFS to ensure any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of threatened and endangered species or result in the destruction or adverse modification of designated critical habitat. The Corps and Bonneville Power Administration (BPA) (federal agencies) fund over 90% of the artificial propagation programs which potentially affect listed spring chinook and winter steelhead in the Upper Willamette River ESUs and therefore must consult under section 7 of the ESA (Figure 2). However, all of the hatcheries included in this consultation are operated and maintained by ODFW. Non-Federal agencies (e.g. ODFW, City of Portland, Portland General Electric) are also required to comply with ESA regulations for their actions that may affect listed anadromous fish. Non-Federal actions only need ESA coverage after section 9 take prohibitions have been promulgated under the 4(d) Rule and are in effect. The 4(d) Rule for the Upper Willamette River ESUs was published on July 10, 2000 (65 FRN 42422). However, take prohibitions will not go into effect until September 8, 2000 for winter steelhead and January 8, 2000 for spring chinook in the

Upper Willamette River. Since take prohibitions are not in effect at this time, non-Federal actions which potentially take listed species do not have to be in compliance with the 4(d) Rule or obtain section 10 permits from NMFS at this point in time.

Even though non-Federal hatchery programs are not required to consult with NMFS at this time, the effects associated with non-Federally funded hatchery programs are included in order to comprehensively assess impacts associated with artificial propagation programs on the listed ESUs. All of the hatcheries are operated by ODFW using primarily federal funds (Figure 2). Inclusion of the non-federal programs operated for the same purposes as the federal programs in this Biological Opinion (Opinion) provides an appropriate, programmatic means to assess the comprehensive effects of regional hatchery operations on the listed ESUs (irrespective of the agency funding the programs), and to derive conclusions regarding whether jeopardy is posed by the collective artificial propagation actions.

The objective of this section 7 Biological Opinion is to analyze actions proposed by Federal and non-Federal action agencies and to determine whether the actions are likely to jeopardize the continued existence of listed species, in particular spring chinook salmon and winter steelhead in the Upper Willamette River ESUs, or result in the destruction or adverse modification of critical habitat designated for these species. This Opinion evaluates the potential effects associated with the collection, rearing, and release of all fish artificially propagated within the Upper Willamette River ESUs. The action agencies did not specify a time duration for this section 7 consultation. NMFS chose this consultation to expire September 30, 2003.

The 4(d) Rule (July 10, 2000; 65 FRN 42422) for the Upper Willamette River spring chinook and winter steelhead ESUs state that it may not be necessary and advisable to prohibit take with respect to artificial production programs, if an HGMP is developed and approved by NMFS. As specified in the proposed rules, the HGMPs must contain specific management measures that will minimize and adequately limit impacts on listed salmonids and promote conservation of the listed ESU. The criteria in the 4(d) Rule are conservation-based and explicit. Once an HGMP is approved, this plan could provide limits to the application of ESA section 9 take prohibitions for the direct (if applicable) and incidental take of listed species associated with hatchery programs in the Willamette Basin. The Federal and non-Federal agencies have initiated development of HGMPs for the Willamette Basin programs which meet the 4(d) Rule criteria. HGMPs have been partially completed and were submitted by the Corps and ODFW for the purposes of this consultation.

The actions proposed in section 2 will only result in the incidental take of listed species. No listed fish are intentionally taken for broodstock into any of the hatchery programs in the Upper Willamette River Basin (i.e. no "direct take" circumstances). Therefore, issuing section 10(a)(1)(A) permits to the appropriate action agency is not necessary once take prohibitions are in effect.

Once finalized, this section 7 consultation will provide an Incidental Take Statement for the hatchery programs included in this Opinion. The action agencies have indicated they intend to develop HGMPs under the 4(d) Rule. If complete HGMPs are received before the end of this consultation period (September 30, 2003), NMFS will evaluate the actions proposed in the HGMPs and determine if reinitiation of this consultation is warranted (as specified in section 11).

In summary, the following is NMFS' application of this Opinion:

- ! Apply this Opinion as the evaluation framework to conclude a formal consultation pursuant to section 7 (a)(2) of the ESA for hatchery programs incidentally affecting listed spring chinook and winter steelhead in the Upper Willamette River ESUs;
- ! If complete HGMPs are submitted by federal and non-federal hatchery operators for programs reviewed in this Opinion before the end of the consultation period, NMFS will evaluate the actions in the HGMPs and determine if reinitiation of this consultation is warranted. If it is determined that reinitiation of this consultation is not necessary, this Opinion will continue to serve as the mechanism for limiting take prohibitions for federal hatchery operations in compliance with the complete HGMPs and for entering into formal agreements with non-federal agencies in accordance with the final 4(d) Rule limits for hatchery programs.

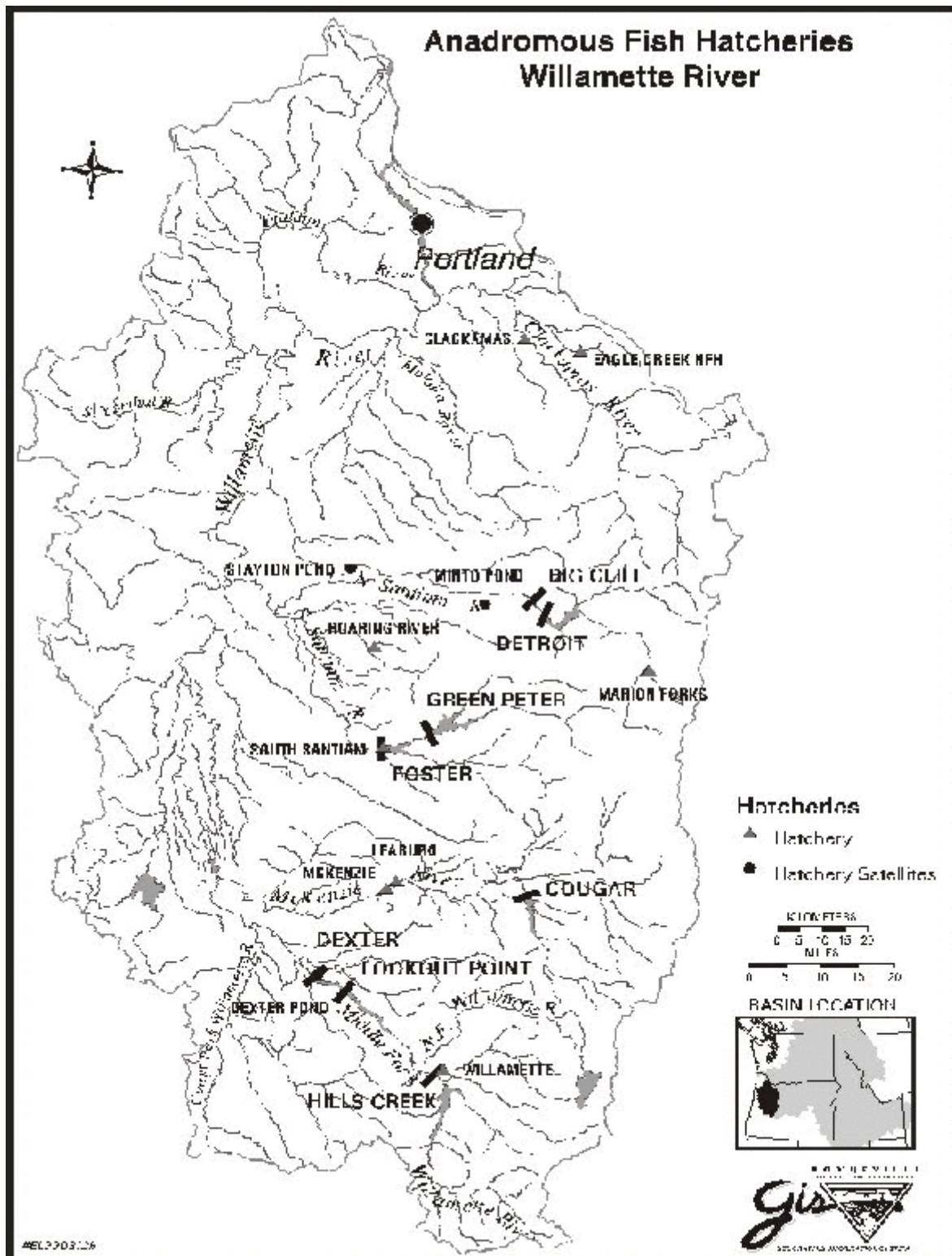


Figure 1. Map of the Willamette River Basin, Oregon, including the location of fish hatcheries.

1.3 Overview of Artificial Propagation

A significant number of scientific papers have examined the potential beneficial effects and risks to natural salmon populations posed by artificial propagation operations and fish production (for example Lichatowich and McIntyre 1987; Hard et al. 1992; Witty et al. 1995; Waples 1999). In particular, the benefits and risks associated with the use of hatchery-based supplementation to recover depleted salmon populations has recently received extensive attention in the literature (for example Steward and Bjornn 1990; Cuenco et al. 1993; Busack and Currens 1995; Waples 1996; Bugert 1998; Flagg and Nash 1999).

Drawing from the above literature, following is an overview of benefits and risks to natural salmonid populations that may be associated with artificial propagation programs evaluated in this Opinion.

1.3.1 Benefits

Hatchery-based supplementation programs (defined as the use of hatchery fish to increase natural production in the wild) may be used to reduce the risk that a population on the verge of extirpation will be lost by expeditiously boosting the number of emigrating juveniles in a given brood year. Supplementation may also be used to preserve or increase the abundance of salmonid populations while other factors causing decreased abundances are addressed. An additional benefit of supplementation is its use to accelerate recovery of populations by increasing abundances in a shorter time frame than may be achievable through natural production. Increasing the “nutrient capital” in the freshwater ecosystem supporting natural salmonid populations by increasing the numbers of decomposing supplementation program-origin salmonid carcasses in a watershed post-spawning is another benefit. This form of artificial production may also be used to establish a reserve population for use if the natural population suffers a catastrophic loss. Reseeding vacant habitat by reintroducing populations to streams where indigenous populations have been extirpated while the causes of extirpation are being addressed is another potential benefit. Finally, these hatchery programs may be used to collect and provide new scientific information regarding the use of supplementation in conserving natural populations.

Hatchery programs producing non-listed salmonid species may be used to benefit fisheries. Artificial propagation programs are implemented in the action area to provide surplus fish for harvest in Pacific Northwest and California commercial, tribal, and recreational fisheries. These non-listed fish production programs are also used to meet international harvest objectives set forth under the Pacific Salmon Treaty agreement, and to mitigate for natural salmonid production losses due to habitat blockage and degradation.

1.3.2 Risks

Artificial propagation programs, including supplementation and reintroduction strategies, may pose significant ecological and genetic hazards to listed, natural-origin salmonid populations (see Figure 29 for a general overview of the potential effects of hatcheries). Hatchery programs may also exacerbate harvest impacts on listed fish by increasing incidental mortality in fisheries targeting surplus hatchery-origin salmonids. The presence of hatchery fish may lead to an inaccurate assessment of the health of natural populations and their habitat, especially if hatchery fish cannot be differentiated from natural-origin fish on the spawning grounds.

Ecological hazards may include disease transfer, facility failure leading to fish loss, increased resource competition, and predation (Steward and Bjornn 1990). Hatchery effluent has the potential to transport fish pathogens out of the hatchery, where natural fish may be exposed to infection. Interactions between hatchery fish and natural fish in the environment may also result in the transmission of pathogens, if either the hatchery or natural fish are harboring a fish disease. Catastrophic loss of listed fish under propagation in a hatchery may occur as a result of de-watering due to power failure or screen fouling, flooding, or poor fish cultural practices. Hazards associated with adverse competitive effects of hatchery-origin salmonids on listed, natural-origin fish may include food resource competition, competition for spawning sites, and redd superimposition. Direct predation (direct consumption) and/or indirect predation (increases in predation by other predator species due to enhanced attraction) may result from hatchery salmonid releases in freshwater and estuarine areas where listed fish are present.

Genetic hazards associated with supplementation, and the production of other races of the same species may include loss of genetic variability within and among populations, domestication, and extinction (Busack and Currens 1995). Within population diversity loss caused by hatchery practices may potentially lead to a loss in fitness of the supplemented or natural population (inbreeding depression) and changes in gene frequencies (genetic drift). Diversity loss within a population may also occur when the population is in the hatchery, causing selection for hatchery production traits that reduce the fitness of the population for the natural environment (domestication selection) (Busack and Currens 1995; Waples 1999). Loss of genetic variability among populations resulting from mating of unrelated populations (e.g. non-indigenous origin hatchery fish spawning in the wild with natural-origin fish) may lead to decreased fitness, limiting the potential of the species to adapt to new environmental conditions, thereby reducing its capacity to buffer the total productivity of the resource against periodic or unpredictable changes (Cuenco et al. (1993) quoting Riggs 1990).

The above potential risks to listed fish posed by artificial propagation operations are reviewed and addressed more specifically in section 5 of this Opinion.

1.4 Hatchery Reform

The effects of hatchery program activities in the Upper Willamette River ESUs have been cited by NMFS' status reviews as potential factors for the decline of these ESUs (Busby et al. 1996; Myers et al. 1998). Interbreeding among hatchery-origin and natural-origin fish and the incidental harvest of listed fish in commercial and recreational fisheries targeting abundant hatchery runs were identified as of particular concern.

The general need for hatchery reform within the Pacific Northwest region, to ensure that existing natural salmonid populations are conserved, and that hatchery-induced genetic and ecological effects on natural populations are minimized, has been

highlighted in several reviews. Focusing on hatchery reform needs in the Columbia River Basin, the following reviews present important perspectives regarding hatchery effects, and the programmatic need for fundamental changes in how hatcheries are operated commensurate with natural salmonid population preservation objectives: *Upstream: Salmon and Society in the Pacific Northwest* (1996); *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem* (ISG 1996); *Review of Salmonid Artificial Production in the Columbia River Basin: As a Scientific Basis for Columbia River Production Programs* (ISAB 1998); *Artificial Production Review - Report and Recommendations of the Northwest Power Planning Council* (NPPC 1999); and *A Conceptual Framework for conservation Hatchery Strategies for Pacific Salmonids* (Flagg and Nash 1999). These documents served as the framework for hatchery program evaluation and reform in this consultation.

Key Issues for Hatchery Management in the Willamette Basin

1. Hatchery spring chinook cannot be differentiated from naturally-produced fish on the spawning grounds and in hatchery broodstocks.
2. Possible significant interbreeding between hatchery fish and natural fish in the wild resulting in the loss of local adaptation among the wild populations. Actual level of hatchery fish straying is uncertain.
3. The majority of hatchery production in the basin is to mitigate for habitat loss and degradation from Federal dams. However, the abundance of hatchery fish promotes fisheries which may significantly impact the remaining listed fish populations.

Due to the recent status of natural-origin winter steelhead and spring chinook in the Willamette Basin, the action agencies have already implemented significant changes to the management of hatcheries and

harvest in the basin. Most of these changes were implemented in the last 5 years and not enough time has elapsed to realize the full benefits of these management changes.

1.5 Evaluating Proposed Actions

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined by 50 C.F.R. Part 402 (the consultation regulations). Procedures for conducting consultation under section 7 of the ESA are further described in the USFWS and NMFS (1998) ESA Consultation Handbook. The general steps for determining jeopardy, and how they are organized in this Opinion, are described below.

The NMFS must determine whether the proposed action is likely to jeopardize the listed species and/or whether the action is likely to destroy or adversely modify critical habitat. This analysis involves the following: (1) Defining the biological requirements of the listed ESUs; (2) describing the current status of the listed ESUs and their habitats under the environmental baseline; (3) evaluating the effects of the proposed action on the listed ESUs; (4) considering the cumulative effects on the listed ESUs; and (5) determining if the proposed action, together with the cumulative effects, is likely to jeopardize the continued existence of the listed ESUs or result in the destruction or adverse modification of its designated critical habitat. The way NMFS applies these steps to hatchery programs affecting listed species is described in more detail in Appendix B. If the effects of the proposed action, taken together with the cumulative effects, are found to jeopardize the listed species, or destroy or adversely modify critical habitat, then NMFS must identify reasonable and prudent alternatives, if there are any, to the proposed actions.

The five steps of the jeopardy analysis completed in this Opinion are as follows: (1) The biological requirements for each Willamette River ESU are described by first setting the stage with descriptions of the listed species and the general habitat characteristics that support these species (sections 3.1 and 3.2); (2) the descriptions of the current status of each ESU and populations is given in section 3.3; (3) the analysis of the factors leading to the current status of the species and its habitat are discussed in the environmental baseline (section 4); (4) the analysis of the effects of the proposed actions is given in section 5; (5) cumulative effects are described in section 6; and (6) the jeopardy/no-jeopardy determinations for each ESU, and determinations of destruction or adverse modification (or not) of designated critical habitat, are given in section 7.

The “action area” for a consultation is defined as “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.” (50 CFR 402.02). The action area encompasses the entire Willamette River Basin from the mouth to the uppermost range of the defined ESUs. Indirect effects of the proposed action are also evaluated in the mainstem Columbia River from the mouth of the Willamette River to the estuary (approximately 100 miles downstream).

In order to conduct sound jeopardy analyses, the appropriate spatial and temporal scales must be used. Spatial scales in freshwater ecology are often confounded by the inconsistent use of hydrologic terms such as basin, subbasin, and watershed. For example, the McKenzie River drainage is referred to as a “basin” by ODFW (1995), a “subbasin” by WNF (1994), and a “watershed” by NPPC (1999). Fortunately, hydrologic terms have been standardized by USGS, which uses a hierarchical system called hydrologic unit codes (HUC) to classify drainages of different sizes, the largest and 2nd largest of which are regions and subregions (e.g., Pacific Northwest and Columbia River drainage, respectively). Subregions are divided into the 3rd largest unit and called “basins”, which are then divided into “4th field HUCs” and called “subbasins”. The subbasins are further divided into “5th field HUCs” and called “watersheds” (PNERC 1998). In this Opinion, USGS’s hydrologic terminology is used; the Willamette River drainage is considered a basin, and 4th field HUCs are considered subbasins (e.g., the subbasins identified for the Upper Willamette ESUs in Table 1 are 4th field HUCs). Smaller units such as 5th or 6th field HUCs are considered watersheds.

In addition to the spatial scales, the temporal scale for the ESU-specific jeopardy analyses in this Opinion must also be defined. That is, over what timeframe shall the effects of the action be considered for each species? This is an important consideration because the longer the timeframe for an action having an adverse effect, the more harmful the effects of the action are likely to be on the affected species. This is particularly true if the proposed action will continue for multiple generations of the species over most, or all of its range. Since the proposed actions in this consultation have been occurring in the past, the analysis of effects in this consultation considered the long-term effects (>10 years) of artificial propagation programs in the Willamette Basin.

NMFS has not defined populations within the Upper Willamette River spring chinook and winter steelhead ESUs. However, for the purposes of this Opinion, 4th field HUCs will be used in the analysis of the effects of the proposed action on the listed ESUs. This geographic scope seems reasonable given the guidance for identifying natural populations in NMFS’ Viable Salmon Populations document (NMFS 2000). This conservative approach analyzes impacts at the subbasin level (i.e. 4th field HUCs) as compared to the geographic scale of the entire ESUs. NMFS’ management guidance related to fisheries and hatcheries has also been to evaluate impacts at the subbasin level.

Healey and Prince (1995) argue that the appropriate conservation unit for anadromous salmonids is the population and its habitat because maintaining genetic (genotype) and morphological, physiological, and behavioral (phenotype) diversity depends on subbasin-scale habitat diversity and the population’s ability to use it. That is, the genetic variability within a population is not physically expressed in the absence of the range of habitat diversity historically found in anadromous salmonid subbasins. This also supports ODFW’s designation of subbasin-scale populations in the Willamette, while emphasizing the importance of suitable and diverse habitat at this scale. Thus the spatial scales for describing the environmental baseline and determining the effects of the proposed action in this Opinion will be the

subbasins delineated in Table 1.

2 Description of the Proposed Action

The action agencies propose to release artificially produced anadromous and resident salmonids into waters where listed spring chinook and winter steelhead juveniles and/or adults are likely to be present. The action area is the area directly affected by the proposed actions and is defined in this Opinion to be within the geographic boundaries established for Upper Willamette spring chinook salmon and winter steelhead ESUs (March 24, 1999 64 FRN 14308; March 25, 1999 64 FRN 14517). Indirect effects of the proposed actions may occur in areas downstream of the ESU boundaries- in the lower Willamette River, lower Columbia River, estuary, and ocean.

Summary of proposed actions

- ! The action agencies propose to release a total of 5.7 million artificially propagated spring chinook, 570 thousand summer steelhead, and 325 thousand rainbow trout in the Upper Willamette River Basin (does not include releases into Lower Columbia ESUs).
- ! No hatchery winter steelhead are proposed for release in the Upper Willamette River ESUs.

Table 1. Annual release goals of hatchery fish by location and species from artificial propagation programs in the Upper Willamette River ESUs. Subbasins are listed from upstream to downstream based on 4th field HUCs. “N/A” represents hatchery production addressed in the hatchery Biological Opinion for listed Lower Columbia River chinook and steelhead ESUs. The impacts from these programs on listed UWR ESUs are assessed in Section 5.

Release Location	Spring Chinook	Fall Chinook	Winter Steelhead	Summer Steelhead	Coho Salmon	Rainbow Trout	Total
Coast Fork Willamette Subbasin	0	0	0	0	0	200,000	200,000
Middle Fork Willamette Subbasin	1,427,240	0	0	157,000	0	0	1,584,240
Upper Willamette Subbasin	0	0	0	0	0	0	0
McKenzie Subbasin	985,000	0	0	108,000	0	125,000	1,218,000
South Santiam Subbasin	1,021,000	0	0	144,000	0	0	1,165,000
North Santiam Subbasin	667,000	0	0	161,500	0	0	828,500
Middle Willamette Subbasin	0	0	0	0	0	0	0
Yamhill Subbasin	0	0	0	0	0	0	0
Molalla Subbasin	100,000	0	0	0	0	0	100,000
Tualatin Subbasin	0	0	0	0	0	0	0
Clackamas Subbasin	1,257,700	0	n/a	n/a	n/a	0	1,257,700
mainstem Lower Willamette River	260,000	n/a	0	0	n/a	0	260,000
Columbia River estuary*	900,000	n/a	n/a	n/a	n/a		900,000
TOTAL	6,617,940	0	0	570,500	0	325,000	7,513,440

* Juvenile releases in the estuary are from broodstock collected in the Upper Willamette spring chinook ESU.

The Corps of Engineers, NMFS, BPA, ODFW, City of Portland, and Portland General Electric (PGE) fund the costs associated with artificial propagation programs in the Upper Willamette ESUs (Figure 2). However, the majority of the funding is provided by Federal agencies. All of the hatchery facilities are operated and maintained by ODFW.

The hatchery programs which collect and rear listed ESU fish provide a more detailed explanation of

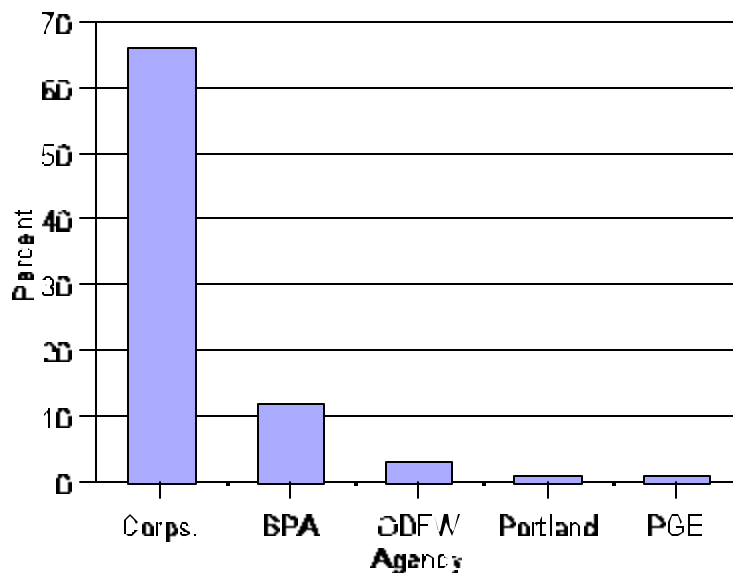


Figure 2. Agency responsibility for the funding of production of the annual hatchery fish releases. Only releases covered by this Opinion are included. Data from ODFW (2000).

the proposed actions. The descriptions of the hatchery programs that propagate summer steelhead and rainbow trout, which are not part of the listed ESUs, focuses on the actions relevant to evaluating potential impacts to the listed ESUs.

Below are the specific proposed actions within each subbasin of the Upper Willamette River ESUs. The programs are detailed by subbasins, species, then hatchery program. Some of the programs transfer hatchery fish to facilities in different subbasins for rearing or release. For these programs, the appropriate hatcheries are listed.

2.1 Clackamas Subbasin

2.1.1 Spring chinook salmon

Clackamas Hatchery

Spring chinook salmon production at Clackamas Hatchery is funded by ODFW (29.6%), Portland General Electric (22%), and the City of Portland (18.8%) (ODFW 1996). Mitchell Act also provides 29.6% of the funding for this spring chinook program. However, all Mitchell Act funded hatchery operations are being evaluated in the hatchery Biological Opinion for the Lower Columbia River ESUs.

Stock History- The Clackamas hatchery spring chinook (stock #19) was developed from other Willamette Basin hatchery spring chinook stocked as smolts into Dog Creek, which is adjacent to the Clackamas hatchery facility, beginning in 1976. Since 1990 the broodstock collected for this program has been from fish returning to the Clackamas Hatchery trap.

Purpose and Location- The Clackamas Hatchery is located at approximately mile 23 on the Clackamas River. The Clackamas River flows into the Willamette River approximately 2 miles downstream from Willamette Falls. The purpose of this spring chinook hatchery program is to mitigate for fisheries losses associated with hydropower development and habitat degradation within the sub-basin.

Facilities- Adults are collected at a hatchery trap and held in two holding ponds onsite. Incubation is in 20 stacks of vertical incubator trays with a capacity of 2.2 million eggs. Rearing of juvenile fish occurs within 10 concrete raceways.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Broodstock is collected at a trap located on Dog Creek, a tributary to the Clackamas River. The broodstock goal for the program is 750 adults. Spring chinook returns in excess of broodstock needs are either sold or disposed. No estimate of the number of listed, natural-origin fish taken for broodstock is available. ODFW expects the number of natural-origin fish to be very low (Nandor 2000).

Releases and Identification- Beginning with the 1997 brood, all hatchery spring chinook released have an adipose fin clip. All hatchery fish returns in 2002 will be externally marked.

Fisheries- Hatchery fish returning to Clackamas hatchery are caught in commercial and recreational ocean and freshwater fisheries.

Monitoring and Evaluation- Spawning surveys are conducted in the Clackamas River Basin to obtain information on the abundance and distribution of natural-origin and hatchery-origin spring chinook. Creel surveys are conducted in the lower Clackamas River to determine the effort and catch of the fishery. The abundance of spring chinook and the composition of hatchery and natural-origin fish are monitored at North Fork Dam on the Clackamas River by Portland General Electric.

2.1.2 Fall chinook Salmon

No hatchery fall chinook salmon are proposed for release into this subbasin.

2.1.3 Winter steelhead

Winter steelhead in the Clackamas River have been identified as part of the Lower Columbia River steelhead ESU (Busby et al. 1996). The effects of the winter steelhead program at Clackamas hatchery on listed steelhead will be evaluated in NMFS' Biological Opinion for hatchery programs in the Lower Columbia steelhead ESU.

2.1.4 Summer steelhead

The proposed actions related to summer steelhead in the Clackamas subbasin will be evaluated in the Biological Opinion for hatchery programs in the Lower Columbia steelhead and chinook salmon ESUs.

2.1.5 Rainbow trout

All rainbow trout, defined as *O. mykiss* of non-steelhead origin, stocked for put-and-take fisheries in running waters of the Clackamas Basin where anadromous fish may reside were eliminated in 1999. No releases are proposed.

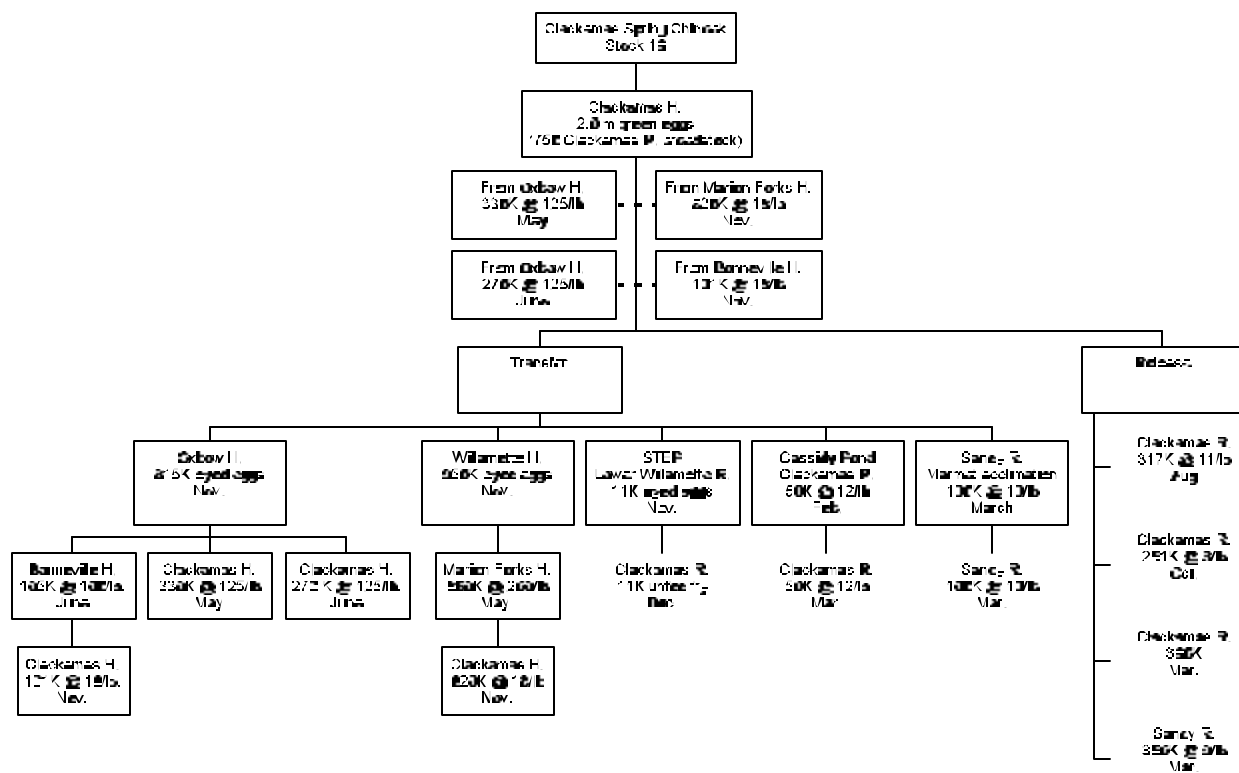


Figure 3. Diagram of the collection, rearing, and release locations of spring chinook at Clackamas Hatchery. From information provided in ODFW (2000b).

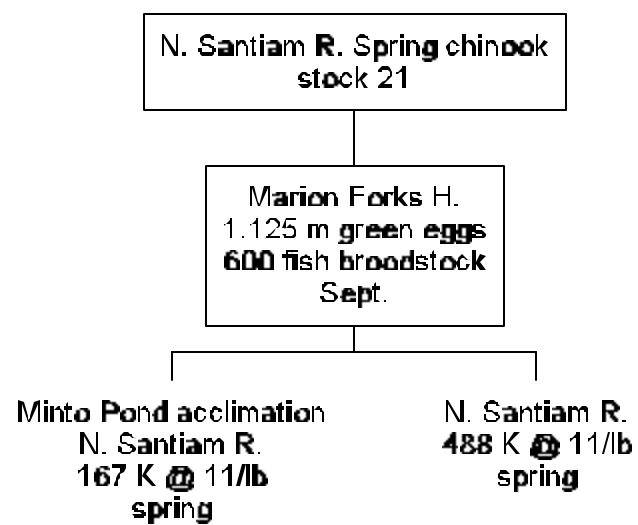


Figure 4. Diagram of the collection, rearing, and release locations of spring chinook associated with Marion Forks Hatchery. Information provided by ODFW (2000b).

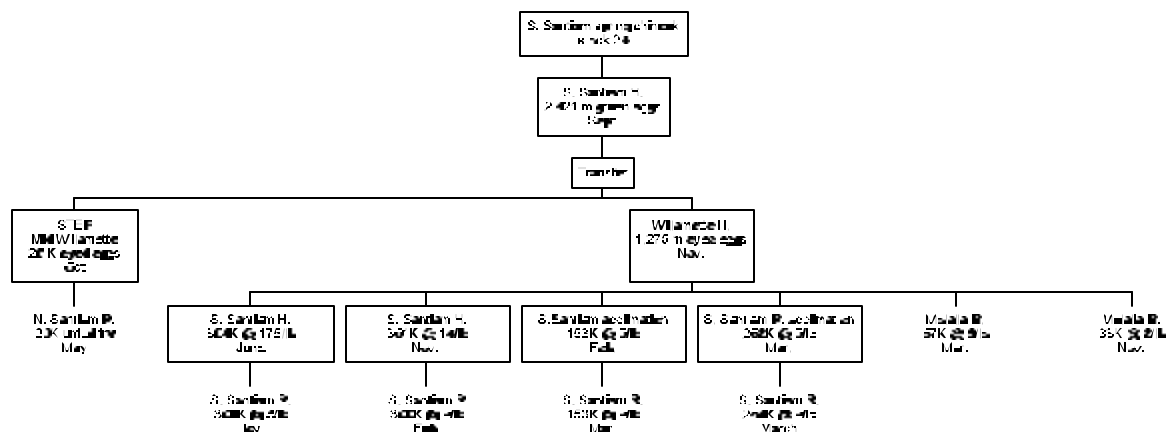


Figure 5. Diagram of the collection, rearing, and release locations of spring chinook associated with South Santiam Hatchery. Information provided by ODFW (2000b).

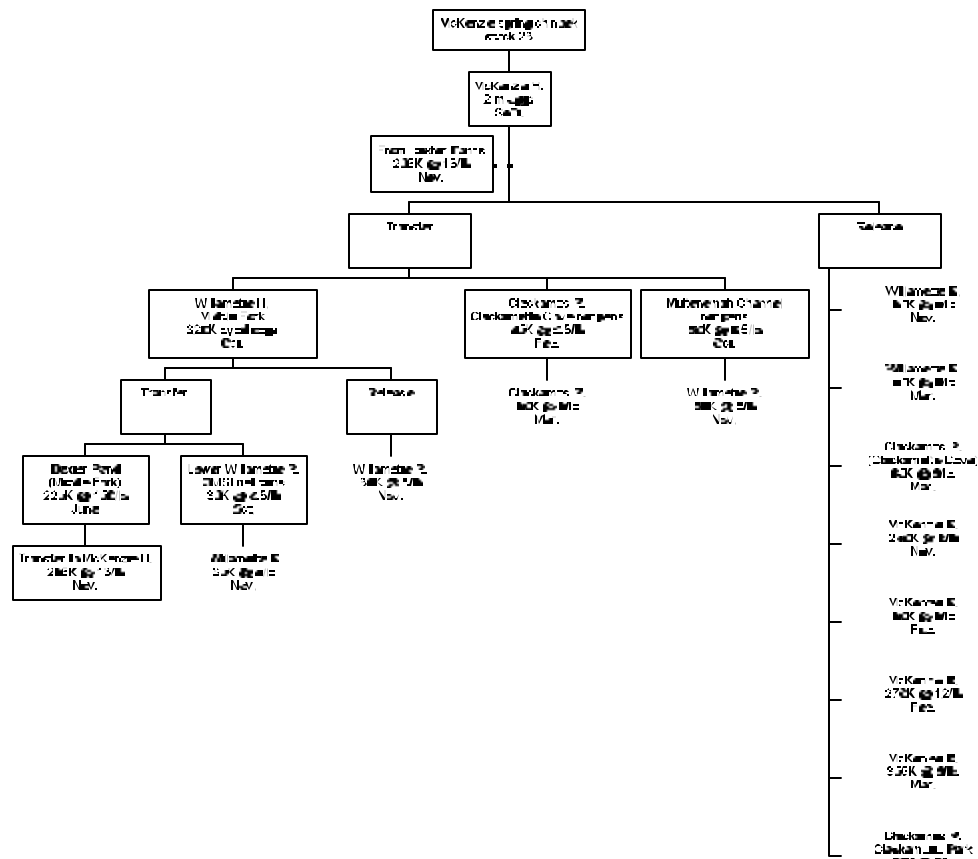


Figure 6. Diagram of the collection, rearing, and release locations of spring chinook associated with McKenzie River Hatchery. Information provided by ODFW (2000b).

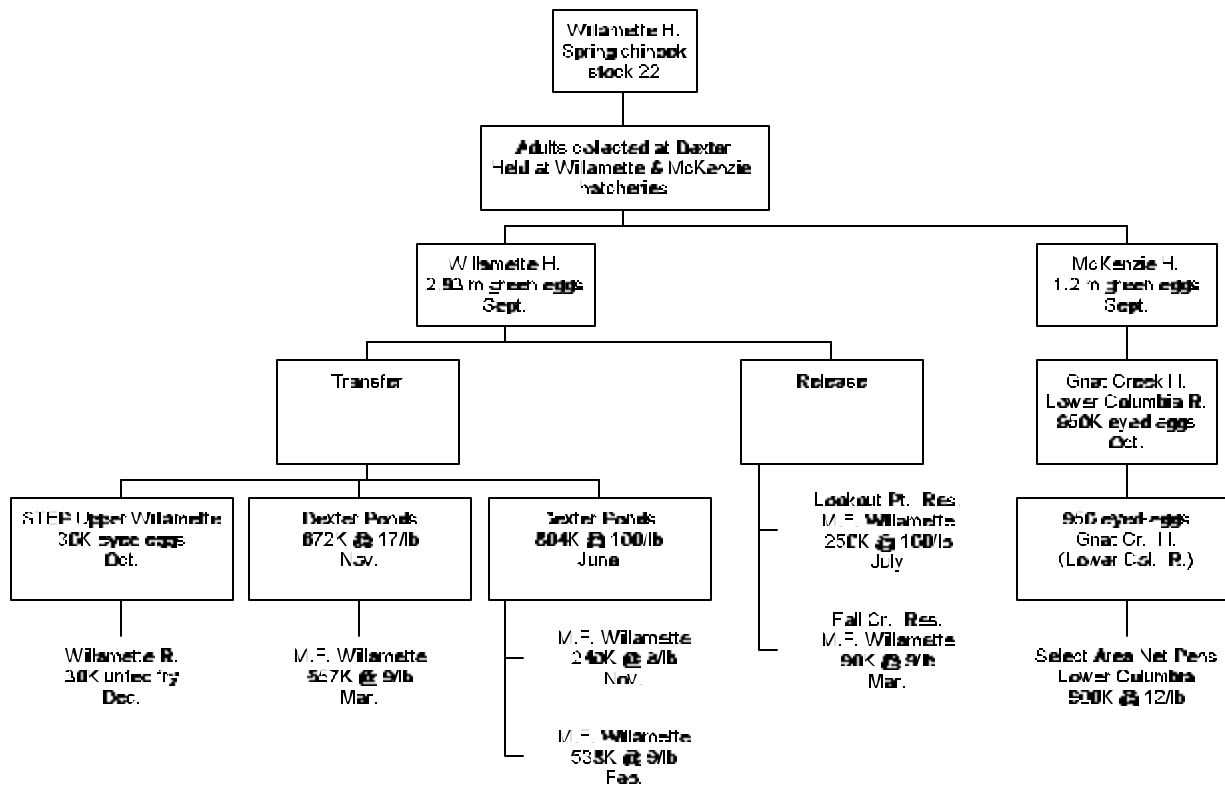


Figure 7. Diagram of the collection, rearing, and release locations of spring chinook associated with Willamette Hatchery. Information provided by ODFW (2000b).

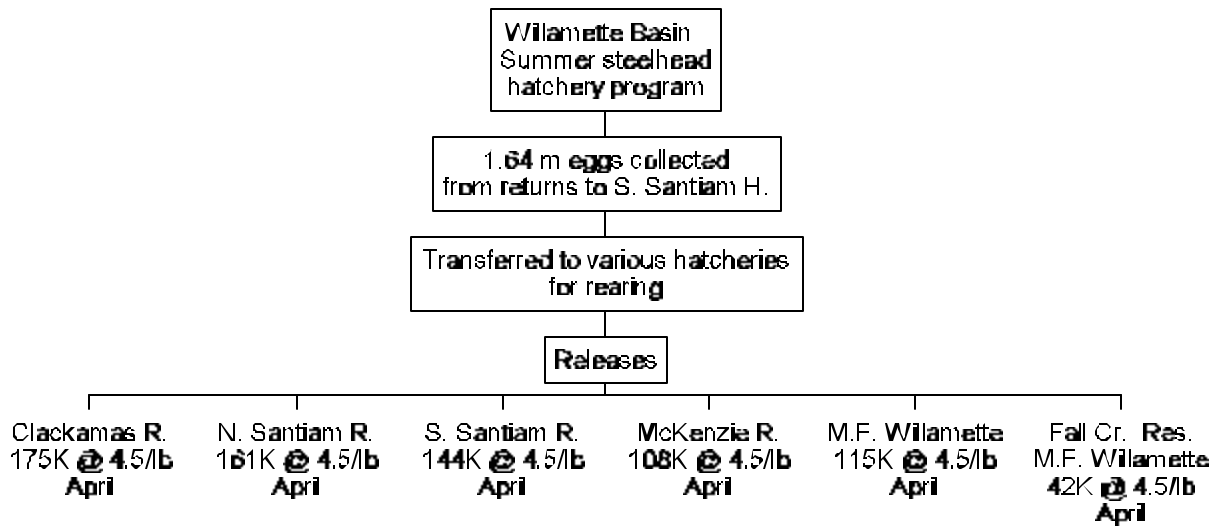


Figure 8. Diagram of the collection and release locations of summer steelhead in the Willamette Basin. Summer steelhead are not part of listed ESU. Only the impacts associated with the collection of adults and the release of juveniles are relevant to this consultation. Information provided by ODFW (2000b).

2.2 Molalla Subbasin

No hatchery facilities are located in the Molalla subbasin. Fish are transferred from other hatcheries and released into the Molalla River. Proposed actions for hatchery fish releases into the Molalla River are specified below.

2.2.1 Spring chinook salmon

South Santiam and Willamette Hatcheries

Spring chinook released into the Mollala River are from broodstock collected at S. Santiam Hatchery. All fish are reared from early egg stage to time of release at Willamette hatchery. The proposed actions for S. Santiam and Willamette hatcheries are detailed below in their respective subbasins.

2.2.2 Fall chinook salmon

No hatchery fall chinook salmon are proposed for release into this subbasin.

2.2.3 Winter steelhead

Releases of hatchery winter steelhead (Big Creek and Santiam stocks) into the Molalla Subbasin were eliminated in 1999. No releases are proposed.

2.2.4 Summer steelhead

Releases of hatchery summer steelhead (Skamania and Santiam stocks) into the Molalla Subbasin were eliminated in 1999. No releases are proposed.

2.2.5 Rainbow trout

All rainbow trout, defined as *O. mykiss* of non-steelhead origin, stocked for put-and-take fisheries in anadromous waters of the Molalla Basin were eliminated in 1999. No releases are proposed.

2.3 North Santiam Subbasin

2.3.1 Spring chinook salmon

Marion Forks Hatchery

The Corps and ODFW fund production of spring chinook at Marion Forks Hatchery. The Corps is responsible for 83.75% and ODFW the remaining costs of the annual production (ODFW 1996).

Stock History- The North Santiam hatchery spring chinook (stock #21) was developed from indigenous spring chinook returning to the base of Detroit Dam. All broodstock used for this program has been from fish returning to the North Santiam River.

Purpose and Location- The purpose of this hatchery program is to mitigate for the loss of spring chinook production associated with the construction of Big Cliff and Detroit Dams on the North Santiam River, which blocked all upstream fish passage. The Marion Forks Hatchery is located above Detroit Dam, on the North Santiam River at river mile 73. The North Santiam River is a tributary to the Santiam River, which flows into the Willamette River.

Facilities- Broodstock are collected at Minto Dam trap, located 33 miles downstream of the Marion Forks Hatchery, on the North Santiam River and held until spawning at the adjacent holding pond. After spawning, eggs are transferred to Marion Forks hatchery for rearing until smolt size. Rearing facilities include 8 raceways, 48 circular ponds and 12 Canadian-style starting troughs (IHOT 1993).

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Broodstock is collected from fish that volitionally enter the trap at Minto Dam. Minto Dam is located approximately 2 miles below Big Cliff Dam and is the uppermost extent of natural fish passage in the North Santiam River. The broodstock goal for the program is 400 fish. Excess spring chinook collected at the Minto trap are either placed upstream of Minto Dam and allowed to spawn naturally in the area between Minto and Big Cliff dams or disposed. The number of listed, natural-origin spring chinook taken for broodstock is not available because hatchery fish cannot be differentiated from natural-origin fish (Nandor 2000).

Releases and Identification- Beginning with the 1996 brood, all hatchery spring chinook released have an adipose fin clip. All hatchery fish returns in 2001 will be externally marked.

Fisheries- Hatchery fish returning from the North Santiam program are caught in commercial and recreational ocean and freshwater fisheries.

Monitoring and Evaluation- Spawning surveys are conducted in the North Santiam Basin to obtain

information on the abundance and distribution of natural-origin and hatchery spring chinook.

2.3.2 Fall chinook salmon

No fall chinook salmon are proposed for release into this subbasin.

2.3.3 Winter steelhead

No hatchery winter steelhead are proposed for release into the North Santiam Subbasin.

2.3.4 Summer steelhead

South Santiam, Oak Springs, and Roaring River Hatcheries

No summer steelhead are raised at the only hatchery facility in the North Santiam subbasin (i.e. Marion Forks). Two groups of fish are raised until smolt size is attained at the South Santiam, Oak Springs, and Roaring River hatcheries. All summer steelhead smolts released into the N. Santiam River are brood from adults collected and spawned at South Santiam Hatchery. One group of fish (121 K smolts) are transferred as eggs from South Santiam Hatchery to Oak Springs Hatchery, Deschutes River Basin, Oregon, for rearing for 5 to 6 months. Fish are then transferred to Roaring River Hatchery (South Santiam subbasin) rearing until smolt size is attained. Smolts are acclimated and released from Minto Pond in the North Santiam River. The second group of fish (40 K smolts) are reared until smolt size at the South Santiam Hatchery. Smolts are also released at Minto Pond on the North Santiam River.

2.3.5 Rainbow trout

All rainbow trout, defined as *O. mykiss* of non-steelhead origin, stocked for put-and-take fisheries in anadromous waters of the N. Santiam Basin were eliminated in 1999. No releases are proposed.

2.4 South Santiam Subbasin

2.4.1 Spring chinook salmon

South Santiam Hatchery

Production of fish at the South Santiam Hatchery is funded by the Corps (70%) and ODFW (30%) (ODFW 1996).

Stock History- The South Santiam hatchery spring chinook (stock #24) was developed from indigenous spring chinook returning to the South Santiam River. Broodstock has been collected entirely from fish returning to Foster Dam on the South Santiam River. However, in some years hatchery spring chinook from other Willamette hatcheries have been planted into the South Santiam River.

Purpose and Location- The purpose of the hatchery program is to mitigate for fishery losses associated with the construction of Foster and Green Peter dams on the South Santiam River. The South Santiam Hatchery is located adjacent to Foster Dam at river mile 38. The South Santiam River is a tributary to the Santiam River, which flows into the Willamette River.

Facilities- Broodstock are collected at the Foster Dam fish collection facility located across the river from the hatchery. Fish are transported to the hatchery and held in a holding pond until spawning. All eggs are transferred to Willamette Hatchery and reared until at least fingerling size.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Broodstock is collected from fish that volitionally enter the fish collection facility at Foster Dam. Sufficient broodstock are collected to produce 2.4 million green eggs (Corps 2000). The mitigation agreement is to compensate for the loss of 1,400 wild spring chinook above Foster Dam. No estimates are available for the number of listed, natural-origin spring chinook taken for broodstock. The ODFW believes no wild spring chinook exist in the S. Santiam River. Spring chinook in excess of hatchery production needs are used to satisfy tribal agreements or properly disposed. From 1996-99, live hatchery chinook collected from the South Santiam Hatchery were also released above Foster Dam (Lorz 2000).

Releases and Identification- Spring chinook salmon from the South Santiam hatchery program are released into the South Santiam, North Santiam, and Mollala rivers. Beginning with the 1997 brood, all hatchery spring chinook released have an adipose fin clip. All hatchery fish returns in 2002 will be externally marked.

Fisheries- Hatchery fish returning from the South Santiam program are caught in commercial and recreational ocean and freshwater fisheries.

Monitoring and Evaluation- The abundance of hatchery and natural-origin fish is monitored at the

Foster Dam trap on the South Santiam River.

2.4.2 Fall chinook salmon

No fall chinook salmon are proposed for release into this subbasin.

2.4.3 Winter steelhead

No hatchery winter steelhead are proposed for release in the South Santiam Subbasin.

2.4.4 Summer steelhead

South Santiam Hatchery

Stock History- The summer steelhead hatchery program in the South Santiam River was initiated from Skamania stock (out of ESU) smolt releases from 1967 to 1973. Since 1973, hatchery summer steelhead returning to the Foster Dam fish ladder on the South Santiam have been collected for broodstock (stock #24).

Purpose and Location- The purpose of the hatchery program is to mitigate for fishery losses, associated habitat loss and degradation associated with Foster and Green Peter dams on the South Santiam River. The South Santiam Hatchery is located adjacent to Foster Dam at river mile 38.5. The South Santiam River is a tributary to the Santiam River, which flows into the Willamette River (rivermile 109).

Facilities- Broodstock are collected at the Foster Dam fish collection facility located across the river from the hatchery. Fish are transported to the hatchery and held in a holding pond until spawning. Offspring are reared until smolt size at South Santiam Hatchery or transferred to other hatcheries (i.e. Bonneville, Oak Springs, McKenzie, Roaring River, Leaburg) for rearing until smolt size is attained.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Broodstock are collected from fish that volitionally enter the fish collection facility at Foster Dam. Sufficient broodstock are collected to produce 1.64 million green eggs (ODFW 2000). Summer steelhead in excess of hatchery production needs are recycled downstream to provide additional fishery harvest or killed.

Releases and Identification- Smolts produced from the South Santiam summer steelhead program are released into the South and North Santiam rivers, McKenzie River, Middle Fork Willamette River, Clackamas River, Sandy River, and Hood River. All smolts are adipose clipped so that they can be differentiated from natural-origin summer steelhead in the Columbia Basin.

Fisheries- Hatchery fish returning from the South Santiam program are caught primarily in freshwater recreational fisheries. Returning fish collected at dam and hatchery facilities are recycled downstream to provide additional fishery harvest.

Monitoring and Evaluation- The abundance of summer steelhead is monitored at the Foster Dam trap on the South Santiam River.

Roaring River Hatchery

Stock History- No adult summer steelhead are collected at Roaring River Hatchery. All broodstock needed for the summer steelhead program in the Upper Willamette River is collected at South Santiam Hatchery (see summer steelhead at South Santiam Hatchery). Roaring River Hatchery is used only for the rearing of juvenile summer steelhead for release into the North Santiam River.

Purpose and Location- The hatchery program was constructed in 1924 and is operated with state funds (IHOT 1993). The hatchery is a mixed stock facility producing both anadromous and resident trout. The hatchery is located along the Roaring River, a tributary of Crabtree Creek, which flows into the South Santiam River.

Facilities- The hatchery has a total of 18 rearing ponds. Six of them were rebuilt in 1987.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- No steelhead broodstock are collected at this hatchery.

Releases and Identification- All summer steelhead reared at Roaring River Hatchery are externally marked before release into the North Santiam River.

Fisheries- Hatchery fish returning to the North Santiam River are caught primarily in freshwater recreational fisheries. Steelhead collected at Minto Dam are recycled through the fisheries or removed from the river.

Monitoring and Evaluation- Standard hatchery monitoring and evaluation as required by IHOT.

2.4.5 Rainbow trout

All rainbow trout, defined as *O. mykiss* of non-steelhead origin, stocked for put-and-take fisheries in flowing waters of the S. Santiam Subbasin were eliminated in 1999. No releases are proposed. However, hatchery trout are stocked into Foster Reservoir where listed winter steelhead and spring chinook may reside.

2.5 McKenzie Subbasin

2.5.1 Spring chinook salmon

McKenzie Hatchery

Production of fish at McKenzie Hatchery is funded by the Corps (50%) and ODFW (50%).

Stock History- The McKenzie hatchery spring chinook (stock #23) was developed from indigenous spring chinook returning to the McKenzie River Basin. All broodstock used for this program has been from fish returning to the McKenzie River.

Purpose and Location- The purpose of this hatchery program is to mitigate for fish production losses associated with the development and operation of Blue River and Cougar dams on the McKenzie River. The McKenzie Hatchery is located on the McKenzie River approximately 22 miles east of Springfield, Oregon. The McKenzie River is a tributary to the Willamette River. The proposed smolt production goal is 1.485 million fish.

Facilities- Rearing facilities consist of 30 raceways, 2 adult holding ponds and 8 Canadian-style starting troughs. Water sources are the McKenzie River and Cogswell Creek. Raceways are supplied with single-pass water and adult holding ponds can be supplied with reused water or fresh single-pass water.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The

IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Broodstock are collected at the hatchery and Leaburg Dam. Based on coded wire tag information, the estimated percentage of the return to the hatchery that has been listed, natural-origin fish has ranged from 13% to 25% since 1996 (Nandor 2000). All returning hatchery spring chinook are removed from the McKenzie subbasin at Leaburg Dam. However, live McKenzie River stock hatchery fish have been released above Cougar and Trail Bridge reservoirs since 1993 (Lorz 2000).

Releases and Identification- Beginning with the 1995 brood year, all hatchery spring chinook released from the program can be differentiated from natural-origin fish based on the presence of an adipose fin clip and/or coded wire tag. Two types of release strategies are conducted- a Fall season release when fish are approximately one year old and a spring release when the fish are 18 months old. Generally, fall releases comprise approximately 20% of the liberations from this program.

Fisheries- Hatchery fish returning from the McKenzie program are caught in commercial and recreational ocean and freshwater fisheries.

Monitoring and Evaluation- Standard hatchery monitoring and evaluation as required by IHOT. Spawning surveys are conducted annually in specific reaches throughout the subbasin.

2.5.2 Fall chinook salmon

No hatchery fall chinook salmon are proposed for release into this subbasin.

2.5.3 Winter steelhead

The McKenzie subbasin is not part of the Upper Willamette River winter steelhead ESU. No hatchery winter steelhead are released into the McKenzie River.

2.5.4 Summer steelhead

Summer steelhead are not indigenous to the Upper Willamette River and not part of the listed steelhead ESU in the Willamette River. The McKenzie River Basin is outside of the geographic boundary for listed winter steelhead. Therefore some of the proposed action sections below related to the hatchery program are not relevant to evaluating the effects on listed spring chinook salmon and winter steelhead in the Willamette Basin. This program is completely funded by the Corps.

South Santiam, Oak Springs, and Leaburg Hatcheries

Stock History- Summer steelhead released into the McKenzie Basin are from broodstock collected and spawned at the South Santiam River Hatchery (stock #24). Subyearlings are transferred from the South Santiam Hatchery to Leaburg and Dexter hatcheries for additional rearing before being released in the McKenzie River.

Purpose and Location- The purpose of this hatchery program is to mitigate for lost trout habitat caused by the construction of Blue River and Cougar dams and other Willamette Valley projects (IHOT 1993). Leaburg Hatchery is located on the McKenzie River approximately 23 miles east of Springfield, Oregon, and is used for egg incubation and rearing of summer steelhead and rainbow trout.

Facilities- See South Santiam and Middle Fork subbasin sections for South Santiam Hatchery and Dexter Hatchery facilities, respectively. Leaburg Hatchery has 40 concrete raceways, 6 circular ponds, 20 aluminum incubation troughs, and 13 starting troughs. Two of the raceways are used for adult capture and holding, 4 for rearing anadromous fish and the remainder of the facilities for the resident trout program.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- No adult summer steelhead are taken for broodstock in the McKenzie River.

Releases and Identification- All hatchery summer steelhead released into the McKenzie River are externally marked.

Fisheries- Hatchery summer steelhead returning from the Leaburg program are harvested predominantly in freshwater recreational fisheries from April through December.

Monitoring and Evaluation- Standard hatchery monitoring and evaluation as required by IHOT.

2.5.5 Rainbow trout

Rainbow trout (stocked as legal-sized fish) are not part of the listed ESUs. The McKenzie River Basin is outside of the geographic boundary for listed winter steelhead. Therefore some of the proposed

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action sections below related to the hatchery program are not relevant to evaluating the effects on listed spring chinook salmon and winter steelhead in the Willamette Basin.

Leaburg Hatchery

Stock History- Rainbow trout (stock # 72) propagated in this hatchery program are not indigenous to the Upper Willamette Basin and not part of the listed ESUs.

Purpose and Location- The purpose of this hatchery program is to mitigate for lost trout habitat caused by the construction of Blue River and Cougar dams and other Willamette Valley projects (IHOT 1993). The hatchery is located on the McKenzie River approximately 23 miles east of Springfield, Oregon, and is used for egg incubation and rearing of summer steelhead and rainbow trout.

Facilities-Leaburg Hatchery has 40 concrete raceways, 6 circular ponds, 20 aluminum incubation troughs, and 13 starting troughs. Two of the raceways are used for adult holding, 4 for rearing anadromous fish and the remainder of the facilities for the resident trout program.

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Not applicable.

Releases and Identification- Rainbow trout are released into the McKenzie River at legal size for put-and-take fisheries. These fish can be distinguished from other fish because of an adipose finclip or by their large size.

Fisheries- Rainbow trout released from this program are caught in recreational fisheries in the McKenzie Subbasin.

Monitoring and Evaluation- Standard hatchery monitoring and evaluation as required by IHOT.

2.6 Middle Fork Willamette Subbasin

2.6.1 Spring chinook salmon

Willamette Hatchery

Production of fish at Willamette Hatchery is funded by the Corps (83.75%) and ODFW (16.25%)

(ODFW 1996). The Bonneville Power Administration funds 50% of the costs accrued for the rearing of spring chinook that are released in the Columbia River estuary.

Stock History- The Willamette hatchery spring chinook (stock #22) was developed from indigenous spring chinook returning to Dexter Pond on the Middle Fork Willamette River. Since 1990, broodstock has been collected entirely from fish returning to the Middle Fork Willamette River. However, previous to 1990, if the number of adult returns was inadequate for broodstock needs, McKenzie River and South Santiam River spring chinook were used to supplement the broodstock.

Purpose and Location- The purpose of the hatchery program is to mitigate for fishery losses caused by Hills Creek, Lookout Point, and the Dexter hydroelectric/flood control projects (IHOT 1996). The Willamette Hatchery is located along Salmon Creek, approximately 3 miles upstream from its confluence with the Middle Fork Willamette River. Site elevation is 1,217 feet above sea level.

Facilities- Adult spring chinook are collected at Dexter Pond, located at the base of Dexter Dam. Broodstock are held and spawned at Willamette Hatchery and McKenzie Hatchery. Willamette Hatchery has 10 raceways, 40 modified Burrows ponds, 4 circular ponds, 2 adult trout brood ponds, and 1 adult salmon holding pond (IHOT 1996). Middle Fork Willamette stock spring chinook spawned at McKenzie Hatchery are used to provide eggs for the Lower Columbia River select-area fishery programs (i.e. Gnat Creek/CEDC programs)

Disease Protocols- All hatchery programs in the Columbia Basin operate under the policies and guidelines developed by the Integrated Hatchery Operation Team (IHOT), a multi-agency group of scientists who developed standardized protocols for spawning and rearing fish in the hatchery. The IHOT guidelines specify protocols for minimizing risks to natural populations from fish health, ecological interactions, and genetics problems.

Broodstock Collection and Disposition of Surplus Adults- Broodstock is collected from fish that volitionally enter Dexter Pond, located at the base of Dexter Dam. Dexter Dam is the uppermost extent of passage. Sufficient broodstock (#22) are collected to produce 4.1 million green eggs (Corps 2000). The mitigation agreement requires an annual production of no more than 235,000 pounds of juvenile chinook salmon and steelhead. The goals of this mitigation production for the Middle Fork Willamette River is to return an average run of 11,250 spring chinook. Spring chinook in excess of hatchery production needs are used to satisfy tribal agreements or properly disposed. However, since 1993 live Willamette stock hatchery chinook have been released above Cougar Reservoir in the McKenzie Subbasin, above Hills Creek, Fall Creek, and Lookout Point reservoirs in the Middle Fork Subbasin (Lorz 2000), and in Mosby Creek, a tributary to the Row River, in the Coast Fork Subbasin (Willamette Hatchery HGMP).

Releases and Identification- Spring chinook salmon from the Willamette Hatchery program are released into the Middle Fork Willamette River below Dexter Dam, Lookout Point Reservoir, Fall Creek, Willamette River, and Lower Columbia River, and the Columbia River estuary. Beginning with the 1997 brood, all hatchery spring chinook released as smolts have an adipose fin clip. A portion of the presmolt releases in the reservoirs are otolith marked and do not have an external fin clip.

Fisheries- Hatchery fish returning from the Willamette Hatchery program are caught in commercial and recreational ocean and freshwater fisheries.

Monitoring and Evaluation- Standard hatchery monitoring and evaluation as required by IHOT.

2.6.2 Fall chinook salmon

No hatchery fall chinook salmon are proposed for release into this subbasin.

2.6.3 Winter steelhead

No winter steelhead are proposed are release in the Middle Fork Subbasin.

2.6.4 Summer steelhead

South Santiam, Oak Springs, Leaburg, and Willamette Hatcheries

Summer steelhead are not indigenous to the Upper Willamette Basin and not included as part of the listed steelhead ESU. Hatchery summer steelhead smolts released into the Middle Fork Willamette River are progeny from steelhead collected at South Santiam Hatchery (see section 2.4.4). Approximately 115,000 hatchery smolts are released into the Middle Fork River in April. An additional 42,000 fish are released into Fall Creek Reservoir within the Middle Fork Subbasin, primarily for trout fishery opportunities.

2.6.5 Rainbow trout

All rainbow trout, defined as *O. mykiss* of non-steelhead origin, stocked for put-and-take fisheries in streams of the Middle Fork Basin where listed fish are likely to reside were eliminated in 1999. No releases are proposed.

2.7 Coast Fork Willamette

2.7.1 Spring chinook salmon

No releases of hatchery spring chinook salmon are proposed for release into the Coast Fork Willamette Subbasin.

2.7.2 Fall chinook salmon

No hatchery fall chinook salmon are proposed for release into this subbasin.

2.7.3 Winter steelhead

No releases of hatchery winter steelhead are proposed for release into the Coast Fork Willamette Subbasin.

2.7.4 Summer steelhead

No releases of hatchery summer steelhead are proposed are release into the Coast Fork Willamette Subbasin.

2.7.5 Rainbow trout

A total of 2,700 rainbow trout are proposed for release annually into the Coast Fork Willamette Subbasin for put-and-take fisheries. These fish are raised at Leaburg Hatchery in the McKenzie Subbasin (see above section for details).

2.8 Other subbasins within the Upper Willamette River ESUs

The subbasins below represent most of the streams flowing into the mainstem Willamette River from the west side of the basin (Figure 1; Table 1).

2.8.1 Upper Willamette Subbasin

This 4th field HUC subbasin includes the Long Tom, Marys, Luckiamute, and Calapooia rivers. No hatchery fish (of any species) are proposed for release in the waters likely containing anadromous fish species.

2.8.2 Middle Willamette Subbasin

This 4th field HUC subbasin includes Rickreall Creek and Mill Creek. No hatchery fish (of any

species) are proposed for release in the waters likely containing anadromous fish species.

2.8.3 Yamhill Subbasin

No hatchery fish (of any species) are proposed for release in the waters likely containing anadromous fish species.

2.8.4 Tualatin Subbasin

No hatchery fish (of any species) are proposed for release in the waters likely containing anadromous fish species.

3 Status of the Species and Their Habitat

3.1 Description of the species and critical habitat

Described below are the general life history and habitat requirements for the Upper Willamette River ESUs. The other ESUs indirectly affected by the proposed actions (see Table 2) are described in Appendix B (NMFS' draft jeopardy standard for hatcheries).

The generalized life history of Pacific salmon and steelhead involves incubation, hatching, and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning. Juvenile rearing in freshwater can be minimal or extended. Additionally, some male chinook salmon mature in freshwater, thereby foregoing emigration to the ocean. The timing and duration of each of these stages is related to genetic and environmental determinants and their interactions to varying degrees. Salmon and steelhead exhibit a high degree of variability in life-history traits; however, there is considerable

debate as to what degree this variability is the result of local adaptation or the general plasticity of the salmonid genome (Ricker 1972, Healey 1991, Taylor 1991). More detailed descriptions of the key features of salmon and steelhead life history can be found in Myers et al. (1998), Healey (1991), and Busby et al. (1996).

Summary of the ESUs

- Currently, there are only three known "wild" naturally-spawning populations of spring chinook in the Upper Willamette ESU. They spawn in the Clackamas, North Santiam, and McKenzie subbasins.
- Winter steelhead are more uniformly distributed throughout the geographic range of the ESU. Naturally spawning populations likely exist in all of the identified subbasins within their ESU.

Chinook salmon is the largest of the Pacific salmon. The species' distribution historically ranged from the Ventura River in California to Point Hope, Alaska in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970). Of the Pacific salmon, chinook salmon exhibit arguably the most diverse and complex life history strategies. Healey (1986) described 16 age categories for chinook salmon, 7 total ages with 3 possible freshwater ages. This level of complexity is comparable to sockeye salmon (*O. nerka*), although sockeye salmon have a more extended freshwater residence period and utilize different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon reside in freshwater for a year or more following emergence, whereas "ocean-type" chinook salmon migrate to the ocean within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. This racial approach incorporates life history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations.

Steelhead also exhibit complex and diverse life history strategies. Juvenile fish can reside multiple years in freshwater before emigrating to the ocean. Freshwater residence by juvenile steelhead has been shown to be up to 7 years (Busby et al. 1996). Adults return after several months to several years in the ocean. Steelhead are iteroparous; they do not die after spawning and can repeat spawn.

Table 2. Summary of salmon species listed under the Endangered Species Act potentially affected (directly or indirectly) by the proposed actions included in this consultation.

Species	Evolutionarily Significant Unit	Present Status	Federal Register Notice
Chinook Salmon (<i>O. tshawytscha</i>)	Snake River Fall Snake River Spring/Summer Lower Columbia River Upper Willamette River Upper Columbia River Spring	Threatened Threatened Threatened Threatened Endangered	57 FR 14653 4/22/92 57 FR 14653 4/22/92 64 FR 14308 3/24/99 64 FR 14308 3/24/99 64 FR 14308 3/24/99
Chum Salmon (<i>O. keta</i>)	Columbia River	Threatened	64 FR 14570 3/25/99
Sockeye Salmon (<i>O. nerka</i>)	Snake River	Endangered	56 FR 58619 11/20/91
Steelhead (<i>O. mykiss</i>)	Upper Columbia River Snake River Basin Lower Columbia River Upper Willamette River Middle Columbia River	Endangered Threatened Threatened Threatened Threatened	62 FR 43937 8/18/97 62 FR 43937 8/18/97 63 FR 13347 3/19/98 64 FR 14517 3/25/99 64 FR 14517 3/25/99

3.1.1 Willamette River Basin

The Willamette River Basin covers approximately 29,800 km² (11,500 mi²). Major tributaries include: McKenzie, Santiam, Calapooia, Molalla, and Clackamas Rivers (Cascade Range) and Long Tom, Marys, Luckiamute, Yamhill, and Tualatin Rivers (Coast Range), although the steelhead ESU does not extend beyond the Calapooia River. The mainstem Willamette River begins at the confluence of the Middle Fork and Coast Fork rivers south of Eugene. The Willamette Basin is composed of 30% valley floor (below 154 m (500 feet)), 60% Cascade Mountain foothills and slopes (up to 3000m), and the remaining area consists of part of the Coast Range (up to 1200 m). The Upper Willamette River ESU is biogeographically different from many of the other ESUs in the Pacific Northwest, in that it was not

glaciated during the late Pleistocene. Climatically, a rainshadow effect, similar to the one influencing the Puget Sound Lowlands, limits rainfall to about 120 cm per year, with minimum rainfalls in July, August, and September. River flows peak in December and January and are sustained for 6 or 7 months of the year. Low flows occur in August and September, although the volume is generally 20% of the peak flow. Summer flows in the Coast Range tributaries are especially low due to the general absence of any substantial snow pack.

3.1.2 Upper Willamette River spring chinook ESU

NMFS identified the Upper Willamette River spring chinook ESU as occupying the Willamette River and tributaries upstream of Willamette Falls, in addition to naturally produced spring-run fish in the Clackamas River. Fall chinook salmon spawn in the Upper Willamette but are not considered part of the ESU because they are not indigenous. None of the hatchery populations in the Willamette River were listed although five spring-run hatchery stocks were included in the ESU (Clackamas, North Santiam, South Santiam, McKenzie, and Middle Fork hatchery stocks).

Upper Willamette River chinook are one of the most genetically distinct groups of chinook in the Columbia River Basin (Figure 10). Historically, passage by returning adult salmonids over Willamette Falls (Rkm 37) was only possible during the winter and spring high flow periods. The early run timing of Willamette River spring-run chinook salmon relative to other Lower Columbia River spring-run populations is viewed as an adaptation to flow conditions at the Falls. Chinook salmon begin appearing in the lower Willamette River in February, but the majority of the run ascends the Falls in April and May, with a peak in mid-May. Low flows during the summer and autumn months prevented fall-run salmon from accessing the Upper Willamette River Basin. Mattson (1963) discusses the existence of a late spring-run chinook salmon that ascended the falls in June. These fish were apparently much larger (25-30 lbs. (11.4-13.6 kg)) and older (presumably 6 year olds) than the earlier part of the run. Furthermore, Mattson (1963) speculated that this portion of the run “intermingled” with the earlier-run fish on the spawning ground and did not represent a distinct run. The disappearance of the June run in the Willamette River in the 1920s and 1930s was associated with the dramatic decline in water quality in the lower Willamette River.

Spring chinook populations in this ESU have a life history pattern that includes traits from both ocean-

Passage Time for Juvenile Salmonids passing Willamette Falls 1992-94

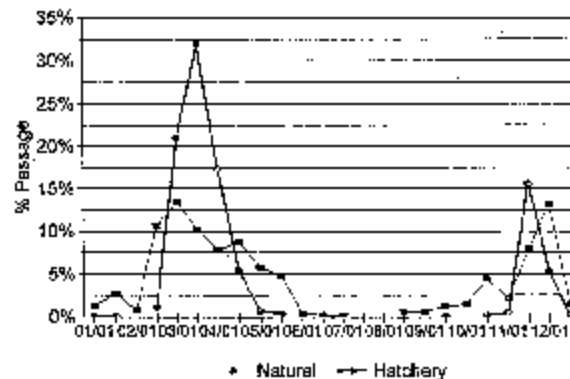


Figure 9. Emigration timing of spring chinook salmon at Willamette Falls. Graph reproduced from Willis et al. (1995).

and stream-type life histories. Smolt emigrations occur as young of the year and as age-1 fish in the fall and spring (Figure 9). Ocean distribution of chinook in this ESU is consistent with an ocean-type life history with the majority of chinook being caught off the coasts of British Columbia and Alaska. Spring chinook from the Willamette River have the earliest return timing of chinook stocks in the Columbia Basin with freshwater entry beginning in February. Adults return to the Willamette River primarily at ages 3 through 5. Spring chinook hold in deep pools for at least several months before spawning. The quality of adult over-summering habitat is critical for their survival. If deep pools do not exist within the stream or stream temperatures are high, significant mortality of adult spring chinook can occur. Historically, spawning occurred between mid-July and late October. However, the current spawn timing of hatchery and natural-origin chinook is September and early October.

Historically, there were five major basins that produced spring chinook including the Clackamas, North and South Santiam Rivers, McKenzie, and the Middle Fork Willamette (Figure 11, Figure 14, Figure 15, Figure 12, Figure 13). However, between 1952-1968 dams were built on all of the major tributaries occupied by spring chinook, blocking over half of the most important spawning and rearing habitat. Dam operations have also reduced habitat quality in downstream areas due to thermal and flow effects. Dams on the South Santiam and Middle Fork Willamette eliminated indigenous spring chinook in those systems (ODFW 1997). Although there is still some natural spawning in these systems below the dams, habitat quality is such that there is probably little resulting production and the spawners are likely of hatchery origin. Populations in several smaller tributaries that also used to support spring chinook are believed to be extinct (Nicholas 1995).

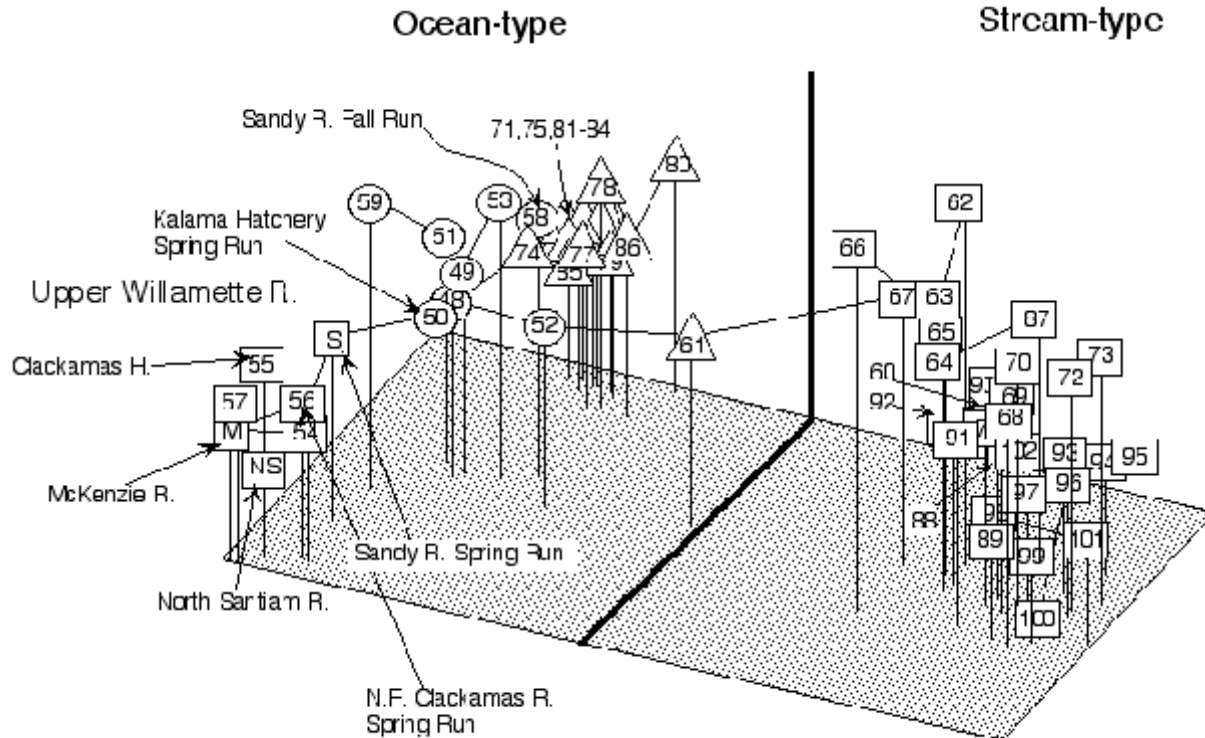


Figure 10. Multidimensional scaling (MDS) of Cavali-Sforza and Edwards (1967) chord distances based on 31 allozyme loci between 57 composite samples of chinook salmon from Columbia River Basin populations. Within the “ocean type” populations, squares designate populations from the Willamette River Basin, circles- Lower Columbia River, triangles- middle and upper Columbia River Basins and Snake River Basins. All “stream type” samples are from the middle, upper Columbia and Snake River Basins. Figures from J. Myers, NWFSC.

3.1.3 Upper Willamette winter steelhead ESU

The Upper Willamette River steelhead ESU includes the Willamette River and its tributaries from Willamette Falls up to and including the Calapooia River. NMFS determined that areas upstream of the Calapooia River (i.e. McKenzie, Middle Fork, Coast Fork subbasins) were not part of the listed steelhead ESU. Historically, winter steelhead were not prominent in these upper headwater areas. The North Santiam River hatchery stock (ODFW stock 21) is part of this ESU and not essential for recovery.

Native steelhead in the Upper Willamette River ESU are known as late-run winter steelhead. The

same flow conditions at Willamette Falls that only allowed access for spring-run chinook salmon also provided an isolating mechanism for this unique run time. Late-run winter steelhead enter the Willamette River from October until May, with peak river entry in January and February (Dimick and Merryfield 1945). However, Howell et al. (1985) reported that the peak passage time at Willamette Falls for “wild” winter steelhead was in April. Redd counts for late-run winter steelhead in the Willamette River Basin are conducted in May (Howell et al. 1985). ODFW currently uses February 15th to discriminate native and non-native Big Creek winter steelhead at Willamette Falls (Kostow 1995). It is generally agreed that steelhead did not historically emigrate farther upstream than the Calapooia River (Fulton 1970).

Steelhead in the Upper Willamette River Basin are heavily influenced by hatchery practices and introductions of non-native stocks. Fishways built at Willamette Falls in 1885, modified and rebuilt several times, have facilitated the introduction of Skamania-stock summer steelhead and early-migrating winter steelhead of Big Creek stock (non-ESU). Production of non-indigenous summer steelhead appears to be low, and the summer population is almost entirely maintained by artificial production (Howell *et al.* 1985). Some naturally-reproducing fish of Big Creek stock winter steelhead may occur in the basin. In 1982, it was estimated that 15% of the late-run winter steelhead ascending Willamette Falls were of hatchery origin (Howell et al. 1985). All releases of hatchery winter steelhead in the ESU have recently been discontinued.

Native steelhead are distributed in a few, relatively small, natural populations throughout the Willamette Basin. Surveys in 1940 reported anecdotal information that steelhead spawned in Gales Creek, a tributary to the Tualatin River (Parkhurst et al. 1950). Numerous introductions of early-run winter steelhead (Big Creek stock) and late-run (North Santiam stock) winter steelhead have been made into the Tualatin River, it is unclear whether the existing fish represent native or introduced lineages.

The Molalla River currently contains three distinct runs of steelhead: native late-run winter steelhead, introduced early-run winter steelhead (from Lower Columbia River populations), and introduced Skamania summer-run steelhead (Chilcote 1997). Releases of the early-run steelhead into the Molalla were recently discontinued (Chilcote 1997).

Genetic analysis indicates a close genetic affinity between winter steelhead populations in the Santiam, Molalla (North Fork), and Calapooia Rivers. Steelhead descended from summer-run (Skamania) and early-run winter (Big Creek) hatchery populations are distinct from the native steelhead.

Native late-winter and introduced Skamania summer-run steelhead are both present in the North Santiam River (Chilcote 1997). Surveys done in 1940 estimated that the run of steelhead was at least 2,000 fish (Parkhurst et al. 1950). Parkhurst et al. (1950) also reported that larger runs of steelhead existed in Breitenbush, Little North Santiam, and Marion Fork Rivers. Native steelhead were artificially

propagated at the North Santiam Hatchery beginning in 1930, when a record 2,860,500 eggs (686 females @ 4170 eggs/female) were taken (Wallis 1963). The release of hatchery propagated steelhead (late-winter run) in the North Santiam was discontinued in 1998 (NMFS 1999). Recent (through 1994) average escapements to the North Santiam have averaged 1,800 fish of mixed hatchery and natural origin (Busby et al. 1996).

Native late-winter and introduced Skamania summer-run steelhead are both present in the South Santiam River. Hatchery releases have not occurred in this basin since 1989, and the proportion of hatchery-reared fish that currently spawn naturally in the South Santiam River is believed to be less than 5% (Chilcote 1997). Hatchery operations began in 1926, and in 1940 a record 3,335,000 eggs were taken (800 females @ 4170 eggs/female); however, it should be noted that river conditions at the hatchery weir site at that time did not allow the weir to be set in place until after a portion of the steelhead run had already passed (Wallis 1961).

ODFW considers the late-run winter steelhead to be one population; however, the abundance trends for populations above and below Foster Dam are very different. The number of redds below Foster Dam has remained relatively stable (albeit at a low level), while the redd count above Foster Dam has declined dramatically in recent years. Live counts of fish passing Foster Dam (1993-1997) have averaged 240 fish, regardless of their origin (ODFW 1998).

Late-run winter steelhead are native to the Calapooia River. Parkhurst et al. (1950) reported that steelhead ascended the Calapooia as far as 87 Km. upstream, although passage at the Finley Mill Dam (RKm 42) may have not been passable during periods of low flow. There is no hatchery program on the Calapooia River, Chilcote (1997) estimates that the percentage of hatchery fish (strays from other Upper Willamette River releases) is less than 5%. This population has declined to very low levels since the late 1980s. In 1993, spawner density estimates for the Calapooia River were at a record low 1.8 spawners per mile (Chilcote 1997). The average escapement of late-run winter steelhead to the Calapooia River (1993-1997) was 61 fish (ODFW 1998). Genetic analysis indicated a close affinity between winter-run steelhead in the Calapooia and native late-run winter steelhead in the Santiam and Molalla Basins.

Naturally spawning winter-run steelhead are currently found in several westside tributaries of the Willamette River; however, there is some debate on the origin of these fish. Parkhurst et al. (1950) did not report the presence of any salmon or steelhead in these systems (although their surveys were conducted during the summertime when adult steelhead would not be present.) Interestingly, Parkhurst et al. (1950) did report on the condition of a number of fish ladders at in-river structures in these tributaries, which suggests that anadromous fish may have been present at some point in time. Hatchery records indicate that large numbers of early-run winter steelhead were stocked into the Luckiamute and Yamhill Rivers. ODFW suggests that, based on spawn timing, late-run winter steelhead may have

recently colonized the Yamhill River (NMFS 1999). Recent genetic analysis of presumptive steelhead from the westside tributaries indicated that fish from the Yamhill River and Rickreall Creek were most genetically similar to steelhead populations from the Lower Columbia River Basin (suggesting the influence of Big Creek winter steelhead or Skamania summer steelhead (NMFS 1999). The sample from the Luckiamute River had no clear affinity with any other steelhead population, and may be descended from resident rainbow trout.

Steelhead are not native to the McKenzie and Middle Fork Willamette subbasin; however there are currently a number of naturally spawning “populations” of late-winter and summer run steelhead that are found upstream of the Calapooia River. These fish are descendants of introductions from hatcheries within and outside of the ESU. Additionally, resident rainbow trout in the McKenzie and Middle Fork Rivers do not genetically resemble steelhead populations in the Willamette River Basin (neither summer, nor early- or late-run winter steelhead) (NMFS 1999). Genetic analysis indicates little resemblance between these resident rainbow trout and hatchery stocks used by ODFW (NMFS 1999). It appears that rainbow trout upstream of the Calapooia have remained fairly isolated from other **O. mykiss** populations in the Willamette River and Lower Columbia River Basin.

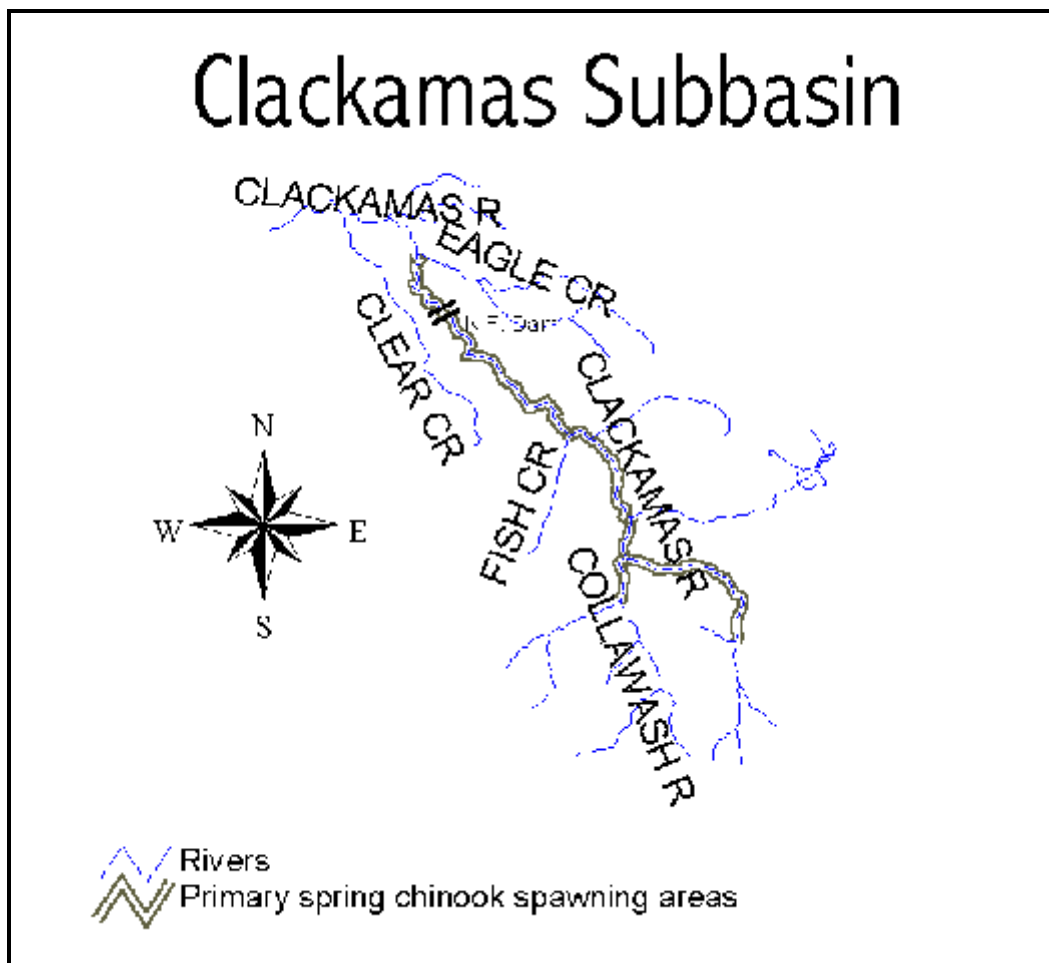


Figure 11. Map of the Clackamas Subbasin. Currently known spring chinook spawning areas are shown (From data in Lindsay et al. 1997, 1998, 1999).

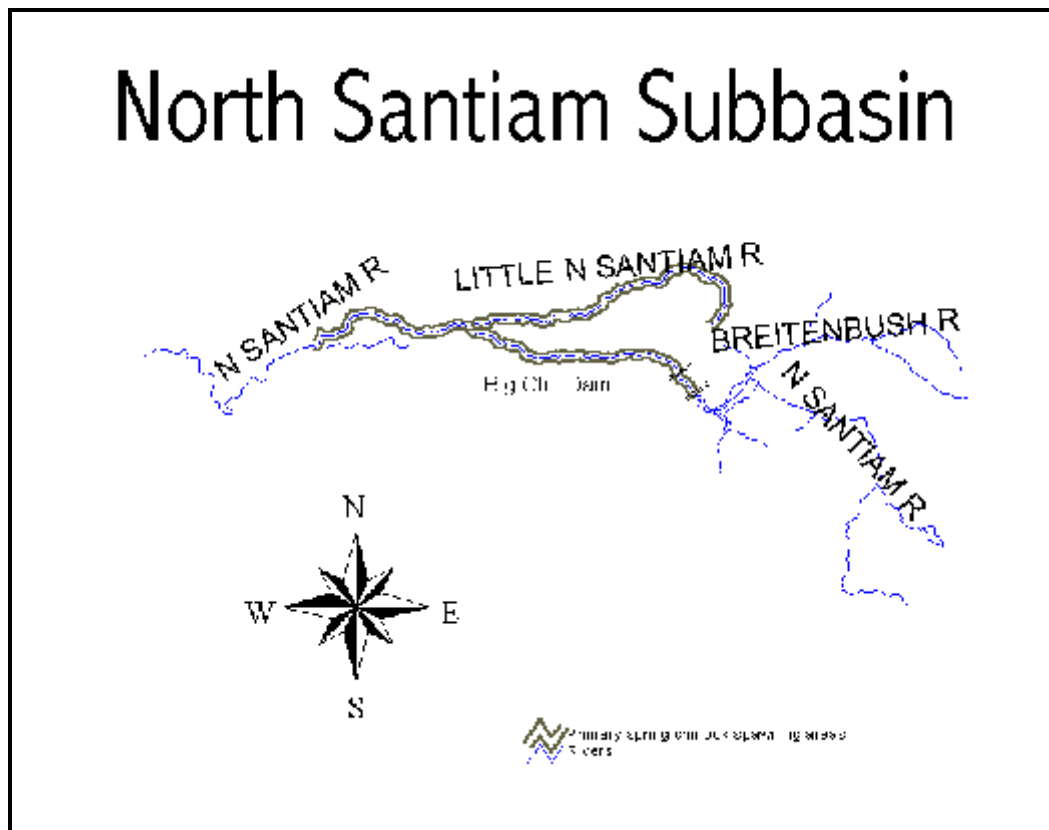


Figure 12. Map of the North Santiam Subbasin. Big Cliff Dam blocks upstream passage of anadromous fish. Currently known spring chinook spawning areas are shown (From data in Lindsay et al. 1997, 1998, 1999). Winter steelhead spawning would likely occur in the North Santiam River below Big Cliff Dam and in the tributaries. Specific information on spawning distribution was not available for winter steelhead.

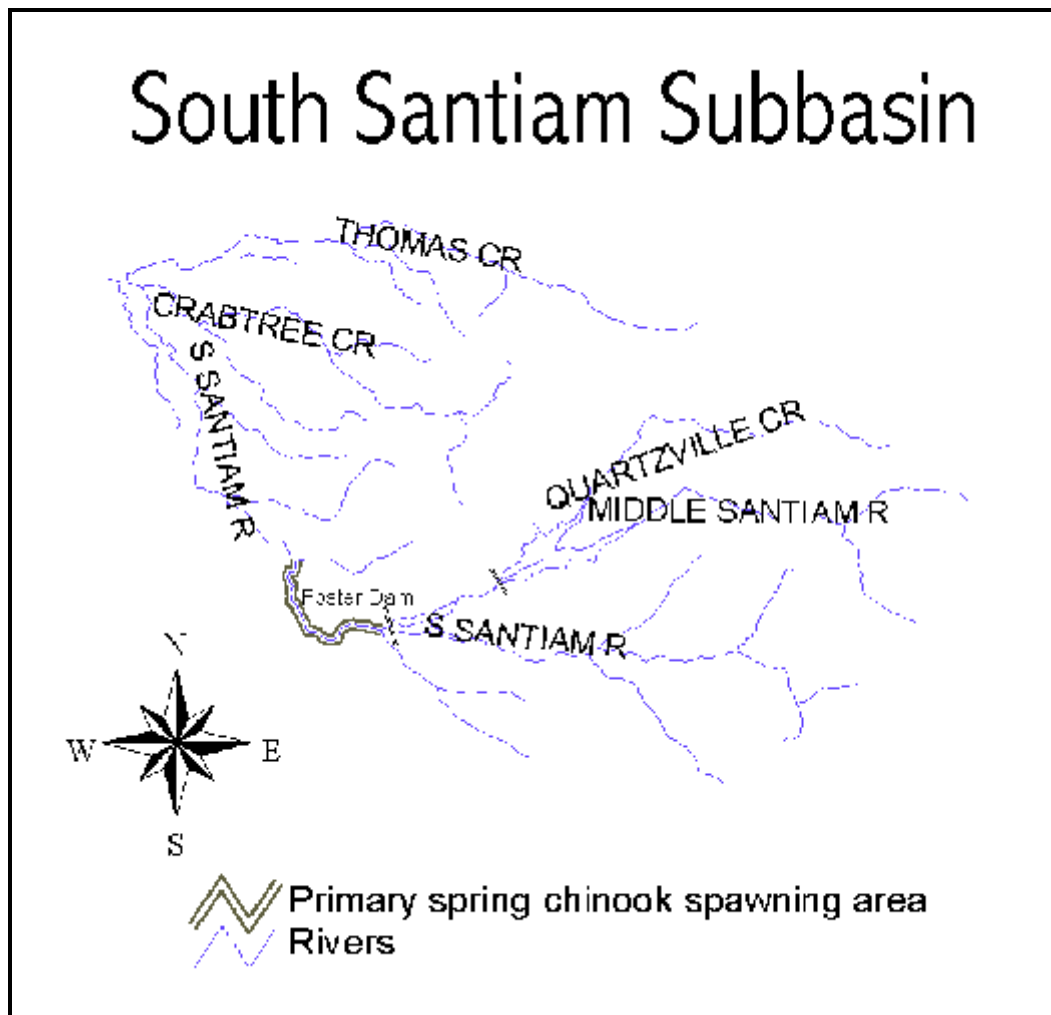


Figure 13. Map of the South Santiam Subbasin. Foster Dam is the uppermost point of natural upstream migration. Trap and haul above the dam can occur. Currently known spring chinook spawning areas are shown (From data in Lindsay et al. 1997, 1998, 1999). Winter steelhead spawning is possible in the South Santiam and tributaries. No specific information on spawning distribution was available.

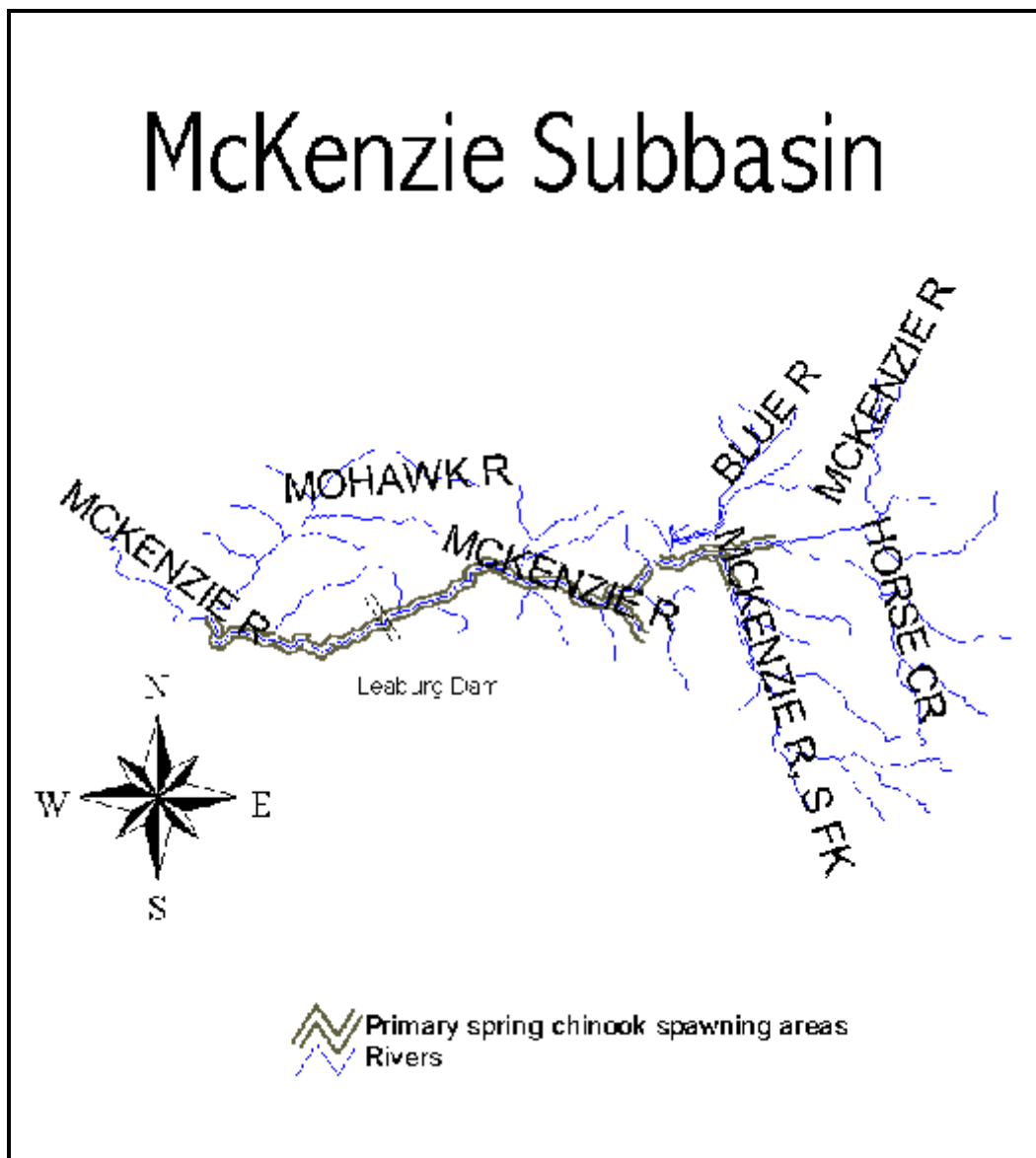


Figure 14. Map of the McKenzie Subbasin. Currently known spring chinook spawning areas are shown (From data in Lindsay et al. 1997, 1998, 1999; ODFW 1999). Winter and summer steelhead that may spawn in this subbasin are not included as part of the listed steelhead ESU.

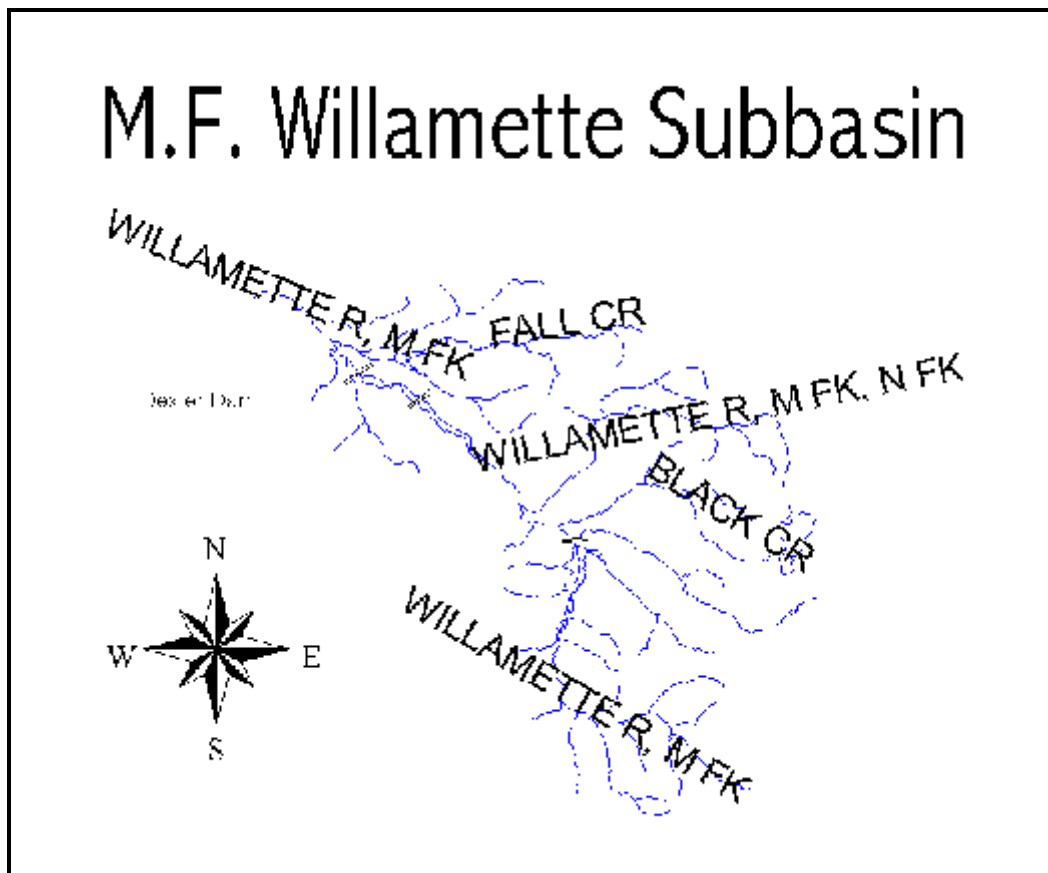


Figure 15. Map of the Middle Fork Willamette River Subbasin. Dexter Dam blocks anadromous fish passage upstream. From 1997-99, this subbasin was surveyed for chinook spawning only in 1998. Ten redds were observed from Dexter Dam to the mouth (Lindsay et al. 1998). Winter and summer steelhead that may spawn in the subbasin are not included as part of the listed steelhead ESU.

3.2 Population Dynamics and Trends

Below is a summary of the abundance of chinook salmon and steelhead in the Upper Willamette River Basin. The status and abundance of fall chinook salmon and summer steelhead are included because their presence has implications to the analysis of the proposed actions. As stated above, fall chinook and summer steelhead are not indigenous to the Willamette River above the Falls and were determined not to be a part of the Upper Willamette River winter steelhead and spring chinook ESUs.

3.2.1 Chinook salmon

There are no direct estimates of the size of the chinook salmon runs in the Willamette River Basin prior to the 1940s. McKernan and Mattson (1950) present anecdotal information that the native American fishery at the Willamette Falls may have yielded 2,000,000 lbs. (908,000 Kgs) of salmon (454,000 fish @ 20 lbs. (9.08 Kgs)). Mattson (1948) estimated that the spring chinook salmon run in the 1920s may have been 5 times the existing run size of 55,000 fish (in 1947) or 275,000 fish, based on egg collections at salmon hatcheries. However, commercial fisheries at Willamette Falls were observing declines in the catch of spring chinook by 1875 (Stone 1875). Additionally, much of the early historical information on salmon runs in the Upper Willamette River Basin come from the operation reports from by state and federal hatcheries.

The abundance of naturally-produced spring chinook in the ESU has declined substantially from historic levels. Historic escapement levels likely exceeded hundreds of thousands of fish per year (Nicolas et al. 1995). From 1946-50, the geometric mean of Willamette Falls counts for spring chinook was 31,000 fish (Myers *et al.* 1998), which represented primarily naturally-produced fish. The most recent 5 year (1995-1999) geometric mean escapement above the falls was 27,800 fish, comprised predominantly of hatchery-produced fish (Figure 16). Nicholas et al. (1995) estimated 3,900 natural

Summary of Abundance and Trends

- The abundance of natural-origin spring chinook has declined significantly from historic levels. The abundance of hatchery spring chinook has increased since the 1950's.
- The total abundance of hatchery and natural-origin chinook has been generally increasing since 1995. The recent average number of fish passing the Falls has been 31,000. However, the number of natural-origin fish is estimated to be only 10% of the total run.
- The abundance of winter steelhead has been relatively stable since 1990. Since 1990 the average number of late-run natural-origin fish at the Falls has been 3,000 fish. The lowest run on record occurred in 1996.

spawners in 1994 for the ESU, with approximately 1,300 of these spawners being naturally produced. There has been a gradual increase in naturally spawning fish in recent years, but it is believed that many of these are first generation hatchery fish. The long-term trend for total spring chinook abundance within the ESU has been approximately stable although there was a series of higher returns in the late-80s and early-90s that were associated with years of higher ocean survival. The great majority of fish returning to the Willamette River in recent years have been of hatchery-origin. The McKenzie, Clackamas, and North Santiam are the primarily basins that continue to support natural production.

The Clackamas River historically contained a spring run of chinook salmon, but relatively little information about that native run exists. Bairn (1886) reported that a run of chinook salmon “commences in March or April, sometimes even in February.” Even in 1885 there were apparent declines in salmon abundance: “... the salmon are not so plentiful now as they were, for some years ago

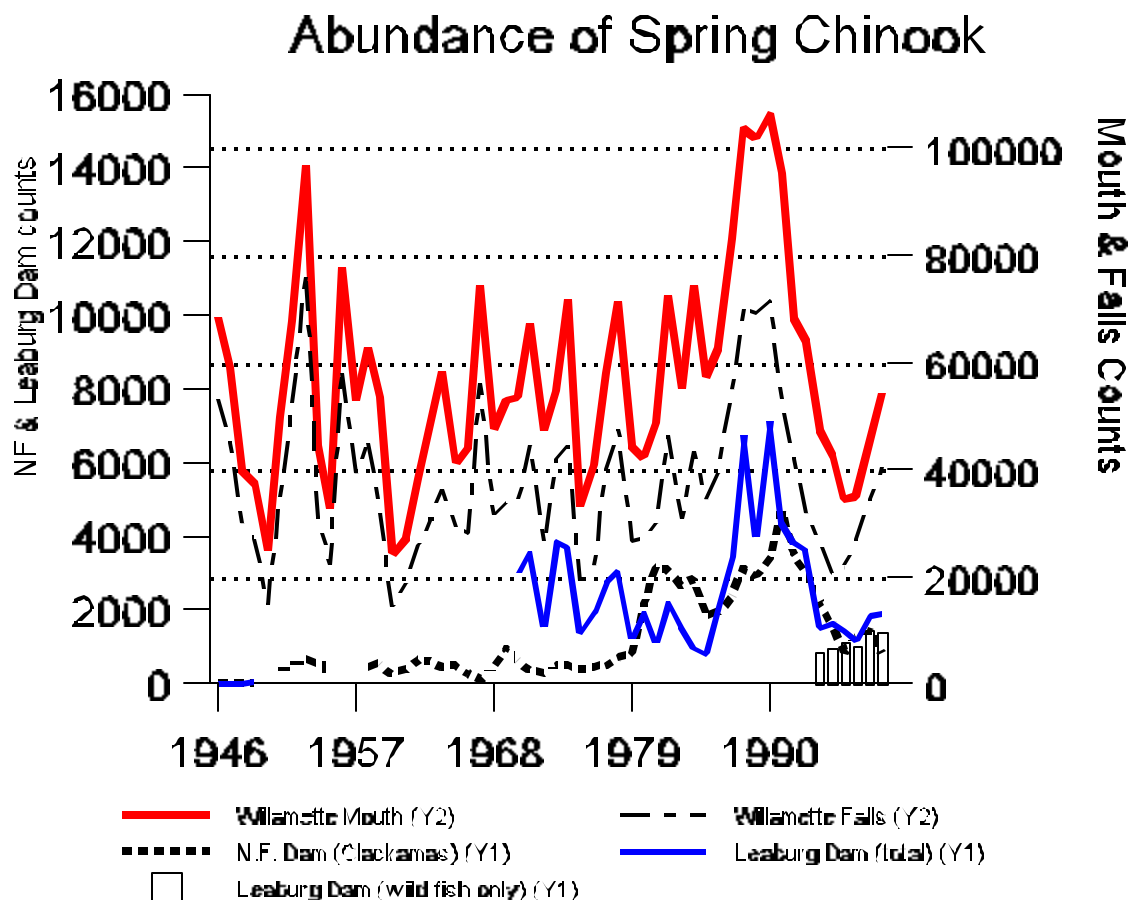


Figure 16. Abundance of spring chinook in the Willamette River Basin. Willamette Falls is located on the Willamette River at river mile 26. N.F. Dam is located on the Clackamas River at river mile 31. Leaburg Dam is located on the McKenzie River at river mile 39.

the river was literally alive with Chinook salmon...” (Bairn 1886). Abernethy (1886) reported that some 3,500 chinook salmon were caught in the Clackamas River between April 10 and July 10, 1885; however he noted that there was no fishing done in the river in March when the run was apparently very large. There are various accounts of when the spring run adults spawned in the Clackamas River. Bairn (1886) mentioned fish spawning in September, although his observations were in the vicinity of Clear Creek (RKm 13) and he might have observed fall-run fish spawning. The U.S. Fish Commission operated two hatcheries: on the upper Clackamas River, Oak Grove Fork (RKm 95), and on the lower Clackamas River (RKm 6). Eggs were collected at the upper Clackamas Station beginning 17 July and ending 26 August, with some five million eggs collected (Ravenel 1898a). At the lower Clackamas Station, ripe fish were not collected until 15 September and by 7 November, 1897, only spawned out fish were collected (Ravenel 1898a). ODFW (1990) suggests that fish collected at the lower Clackamas Station were probably fall-run “tule” chinook salmon. Currently, naturally spawning spring-run chinook salmon spawn from September to October (Olsen et al. 1992).

The construction of the Cazadero Dam in 1904 (RKm 43) and River Mill Dam (Figure 11) in 1911 (RKm 37) limited migratory access to the majority of the historical spawning habitat for the spring run. In 1917, the fish ladder at Cazadero Dam was destroyed by floodwaters, eliminating fish passage to the upper basin (ODFW 1992). Hatchery production of spring-run chinook salmon in the basin continued using broodstock captured at the Cazadero and River Mill Dams (Willis et al. 1995). Transfers of Upper Willamette River hatchery stocks (primarily the McKenzie River Hatchery) began in 1913, and between 1913 and 1959 over 21.3 million eggs were transferred to the Clackamas River Basin (Wallis 1961, 1962, 1963). Furthermore, a large proportion of the transfers occurred during the late 1920s and early 1930s to supplement the failure of the runs in the Clackamas River Basin at that time (Leach 1932). In 1942 spring-run chinook salmon propagation programs in the Clackamas River Basin were discontinued. By 1939, when passage for spring-run chinook salmon was restored over the Clackamas River dams, the spring run population had declined considerably since the turn of the century. A spawner survey conducted in August 1940 observed 300 adults below Cazadero Dam and more than 500 below River Mill Dam (Parkhurst et al. 1950); however, unspecified conditions did not permit these fish to migrate above the dams. A further 500-700 spring-run chinook salmon were observed spawning in Eagle Creek (where the U.S. Bureau of Fisheries Station was sited) in September and October 1941 (Parkhurst et al. 1950).

Recolonization of the upper Clackamas River was somewhat limited. The average annual dam count (River Mill or North Fork Dam) from 1952-59 was 461 (ODFW 1992). More importantly, 30% of the adult passage counts occurred in September and October. Artificial propagation activities were restarted at the Eagle Creek National Fish Hatchery in 1956 using eggs from a number of upper Willamette River hatchery stocks. The program released approximately 600,000 smolts annually through 1985. In 1976, the ODFW Clackamas Hatchery (located below River Mill Dam) began releasing spring-run chinook salmon (Willamette River hatchery broodstocks were used, since it was

believed that the returns from the local population were too small to meet the needs of the hatchery (ODFW 1992)). Increases in adult returns over the North Fork Dam, and increases in redd counts above the North Fork Reservoir corresponded to the initial return of adults to the hatchery in 1980 (ODFW 1992, Willis et al. 1995). Adult counts over North Fork Dam rose from 592 in 1979 to 2,122 in 1980 (ODFW 1992). Spawner surveys conducted in 1998 estimated that 380 redds were present above the North Fork Dam (this corresponded to 1,382 adults passing the dam one week prior to the redd count) (Lindsay et al. 1999).

The Clackamas River currently accounts for about 20% of the production in the Willamette Basin. The production comes from one hatchery and natural production areas located primarily above the North Fork Dam. The interim escapement goal for the area above the Dam is 2,900 adults (ODFW 1998a). This system is heavily influenced by hatchery production so it is difficult to distinguish natural from hatchery-origin spawners. Most of the natural spawning occurs above the North Fork Dam with 1,000-1,500 adults crossing the Dam in recent years. There were 380 redds counted above the dam in 1998 and similar counts in 1997 (Lindsay et al. 1998). There is some spawning in the area below the Dam as well although the origin and productivity of these fish is again uncertain. There were 48 spring chinook redds counted below the North Fork Dam in 1998.

Genetic analysis by NMFS of naturally produced fish from the upper Clackamas River indicated that this stock clustered with hatchery stocks from the Upper Willamette River Basin (Myers et al. 1998). This finding agrees with an earlier comparison of naturally produced fish from the Collawash River (a tributary to the upper Clackamas River) and upper Willamette River hatchery stocks (Schreck et al. 1986). Introductions of fish from the upper Willamette River have significantly introgressed into, if not overwhelmed, spring-run fish native to the basin. Although there is no genetic baseline for the historical population, the significant changes in spawning time from the 1890s to the present would suggest that the native population had been modified or replaced. Furthermore, observed adult passage at the dams indicates that this change had occurred by the early 1950s, before the recent large hatchery programs were initiated at the Eagle Creek NFH (1956) and the Clackamas Hatchery (1976). Finally, increases in spawner abundance in the upper Clackamas River Basin corresponded directly with the first adult returns to the Clackamas Hatchery, suggesting that the present naturally spawning population(s) in the Clackamas River are derivatives of upper Willamette River populations.

It was suggested by ODFW (1998) that spring-run fish returning to the upper Willamette River Basin historically may have strayed into the Clackamas River at times when conditions at Willamette Falls prevented upstream passage. If so, the current genetic similarity of Clackamas River and Upper Willamette River fish might reflect an historical/evolutionary affinity rather than a recent artifact of human intervention.

Spring-run chinook salmon are native to the Santiam River Basin. The Oregon Fish Commission

attempted egg-taking operations in 1906 and 1909, but it was not until 1911 when adults were captured for spawning (Wallis 1963). The hatchery rack was located near Detroit, below the confluence of the North Santiam and Brienbush Rivers, and below where most of the natural spawning areas (except for the Little North Santiam River). It was general hatchery policy to capture as many broodstock as possible. In 1911, 1,500,000 eggs were collected. The largest egg collection was 13,200,000 in 1934 (this would correspond to 4125 females @ 3200 eggs/female (Wallis 1963)). The estimated run size for the entire North Santiam River Basin was 2,830 in 1947 (Mattson 1948). Between 1911 and 1960, the overwhelming majority of hatchery fish released into the North Santiam basin have come from adults captured in the watershed. Other introduction have come from the South Santiam, McKenzie, and Willamette River Hatcheries (Willis 1963). A program to introduce Carson Hatchery spring-run chinook salmon (Snake River and Upper Columbia River populations) at the North Santiam Hatchery during the 1970s was discontinued after several years and appears to have had little impact on the original hatchery population (Willis et al 1995).

The construction of Detroit and Big Cliff Dams (RKm 79; Figure 12) in 1953 on the North Santiam River, eliminated access to approximately 70% of the spawning area for chinook salmon. Additionally, alteration in the temperature and rate of discharge from the dams has probably had a significant impact on the survival of eggs deposited below the dam. Changes in the temperature regime have resulted in accelerated embryonic development rates and premature emergence. Cramer et al. (1996) reports chinook salmon fry in the North Santiam River moving downstream in late November, in contrast to normal emergence in February or March.

The earliest observed spawning at the North Fork Santiam rack occurred on August 22 in 1947, which was earlier than that observed at the McKenzie or Middle Willamette River hatchery racks (Mattson 1948). These spawning differences were ascribed to lower temperatures at the Santiam racks relative to the other sites. During spawner surveys in 1998, no redds were observed prior to September 1 (Lindsay et al. 1999). In 1998, 115 redds were observed in the North Santiam River, with an additional 39 redds in the Little North Santiam River.

Historically, juvenile spring-run chinook salmon began their downstream emigration at a variety of ages and sizes. Studies by Craig and Townsend (1946) in 1941 indicated that juveniles in the North Santiam River began moving downstream in March, soon after emergence. There appeared to be a more or less continuous emigration through the summer and autumn, with none of the previous year's juveniles being present in the tributaries by March of the following year. Analysis of scales from adults returning to the North Santiam indicated that approximately 10% (6 of 65 fish) had entered the ocean as subyearlings (Mattson 1962).

Genetic analysis of naturally produced juveniles from the North Santiam River indicated that the fish were most closely related (although still significantly distinct ($P > 0.05$) to other naturally- and hatchery-

produced spring-run chinook from the Upper Willamette and Clackamas Rivers (Myer et al. 1998).

Spring-run chinook salmon are native to the South Santiam River. Egg collection activities began in 1923 with a weir placed across the river near the town of Foster (Wallis 1961). River conditions did not allow the weir to be put in place until June and it is possible that a considerable portion of the run had already moved upstream at that time. Furthermore, Wallis (1961) noted that the inefficient operation of weir often allowed a number of adults to move upstream. Additionally, in some years the weir was not put in place. The weir was situated well below the natural holding and spawning areas (Mattson 1948). Escapement to the South Santiam River was estimated to be 1300 in 1947 (Mattson 1948). Wallis (1961) estimated that because of poor husbandry practices, releases from the South Santiam Hatchery did not significantly contribute to escapements.

There is little historical information on the life history characteristics of spring-run chinook salmon from the South Santiam River. Juvenile studies by Craig and Townsend (1946) indicated that there was a more or less continuous downstream migration of fish from the time of emergence through the winter. Other life history characteristics are assumed to be similar to other populations in the Upper Willamette River Basin.

In 1966 Foster Dam (RKm 77; Figure 13) blocked access to nearly all historical spring-run chinook salmon spawning areas (Middle Santiam River, Quartzville Creek, and South Santiam River; Mattson 1948). The South Santiam Hatchery currently collects broodstock from a trap near the base of Foster Dam. With the loss of nearly all of their historical spawning habitat spring-run chinook salmon in the South Santiam River have become dependant on artificial propagation for their sustainability. ODFW (1995) considered that the naturally-spawning populations in the South Santiam River were “probably extinct”. In 1998, there were 166 spring-run chinook salmon redds observed in the South Fork; however it is most likely that these are the progeny of hatchery produced spring-run (Lindsay et al. 1999). Fall-run chinook salmon are also present in the Santiam River Basin, but the spring-run and fall-run chinook salmon generally appear to be spatially and temporally separated on the spawning grounds.

Spring run chinook salmon are native to the McKenzie River Basin. Historical natural spawning areas include: mainstem McKenzie River, Smith River, Lost Creek, Horse Creek, South Fork, Blue River, and Gate Creek (Mattson 1948, Parkhurst et al. 1950). Currently, this is the primary population above Willamette Falls to sustain a relatively high level of natural production. Mattson (1948) estimated that there were 4,780 adults returning to the McKenzie River, and that this constituted 40% of the entire run above the Willamette Falls. The McKenzie River Hatchery (RKm 52), which began egg taking operations in 1902, obtained a peak collection of 25,100,000 eggs in 1935 (Wallis 1961), from an estimated 7844 females (@ 3200 eggs per female). In 1998, an estimated 1415 “wild” and 459 hatchery spring-run chinook salmon were counted at Leaburg Dam (RKm 56; Figure 14), while 1690 spring-run adults were collected at the McKenzie River Hatchery (4 Km downstream of the dam)

(Lindsay et al. 1999, ODFW 1999). Furthermore, 113 redds were observed below Leaburg Dam (Lindsay et al. 1999). ODFW (Kostow 1995) has eliminated introductions of hatchery reared juveniles above Leaburg Dam, in an effort to improve the survival of naturally produced juveniles.

The construction of the Cougar Mountain Dam (RKm 101) in 1963 eliminated 56 Km of spawning habitat on the South Fork McKenzie River. USFWS (1959) estimated the escapement of spring chinook above the future location of Cougar Dam to be 4,000 fish in 1958. The Blue River Dam (RKm 88) prevented access to an additional 32 Km of spawning habitat. The Eugene Water and Electric Board (EWEB) power station and associated water diversions at Leaburg began power production in 1910 and Leaburg Dam was constructed in 1930. The Leaburg and Walterville (RKm 40) water diversion canals operated for years without effective screening to prevent juvenile entrainment. Improved screening on the Leaburg diversion was installed in 1985. However, the Walterville diversion canal currently takes approximately one-third of the mainstem McKenzie River water through an unscreened headworks.

Spring run chinook salmon in the McKenzie River historically began spawning in mid-August through to mid-October, with peak spawning occurring around September 10 (Willis et al. 1995). Mattson (1963) reported that a female was spawned as early as 14 August at the McKenzie River Hatchery in 1935. Furthermore, stream surveys in the McKenzie indicate that redds are observed as early as 15 August and as late as 20 October. Juveniles are observed moving downstream beginning in February and continuing throughout the year (Craig and Townsend 1946; Cramer et al. 1996). Analysis of scales from adults returning to the McKenzie River in 1947 indicated that 13.5% (8/59) had entered the ocean as subyearlings. Currently, outmigration of spring chinook occurs primarily in the spring and fall. Lichatowich (1999) suggested the summer emigration period of juveniles has been lost because of habitat degradation (i.e. loss of channel complexity and altered water temperatures).

Genetic analysis of naturally produced juveniles from the McKenzie River (Figure 1) indicated that the naturally produced fish were most closely related to (although still significantly distinct from ($P > 0.05$)) other naturally- and hatchery-produced spring-run chinook from the Upper Willamette and Clackamas Rivers (NMFS 1998).

Prior to construction of major dams on Willamette tributaries, the McKenzie produced 40% of the spring chinook above Willamette Falls and it may now account for half the production potential in the Basin. Despite dam construction and other habitat degradations, the McKenzie still supports substantial production with most of the better quality habitat located above Leaburg Dam. The interim escapement objective for the area above the Dam is 3,000-5,000 spawners (ODFW 1998a). Pristine production in that area may have been as high as 10,000, although substantial habitat improvements would be required to again achieve pristine production levels. Estimates of the number of natural-origin spring chinook returning to Leaburg Dam are available since 1994 when adults from releases of hatchery

reared smolts above the dam were no longer present. The number of natural-origin fish at the Dam has increased steadily from 786 in 1994 to 1,458 in 1999 (Figure 16). Additional spawning in areas below the Dam accounts for approximately 20% of the return to the McKenzie subbasin.

The Middle Fork of the Willamette River historically supported a large population(s) of spring-run chinook salmon. Historically, there were large spawning aggregations in Salmon Creek, North Fork Middle Willamette River, mainstem Middle Fork Willamette River, and Salt Creek (Mattson 1948, Parkhurst et al. 1950; Figure 15). The construction of Lookout Point and Dexter Dams (Rkm 328) in 1953 eliminated access to almost 345 Km of salmon habitat (Cramer et al. 1996). Based on egg collections at the Willamette River Hatchery (Dexter Ponds) (1909-present), the largest egg collection of 11,389,000 in 1918 (Wallis 1962) would correspond to 3559 females (@ 3200 eggs/female). Mattson (1948) estimated the run size to the Middle Fork Willamette River to be 2,550 in 1947. During the construction of Dexter and Lookout Dams, when access to the spawning grounds was completely blocked, 4391 adults were taken in 1953 and 4,334 in 1955 (Wallis 1962). Currently, there is little natural production in the Middle Fork Willamette River. ODFW (1995) determined that the naturally spawning population in the Middle Fork Willamette River is extinct, although there may be some natural production in Fall Creek during high flow years. In 1998, only 10 redds were observed below Dexter Dam, compared with 8,891 adults that returned to the hatchery trap below the dam (Lindsay et al. 1999).

Studies of the emigration of juveniles from the Middle Fork in 1941 indicated that downstream migration occurred on a more or less continuous basis from March through the autumn (Craig and Townsend 1946).

Genetic analysis of naturally produced juveniles from the Dexter Ponds trap (Figure 1) indicated that the fish were most closely related to (although still significantly ($P > 0.05$) distinct from) other naturally- and hatchery-produced spring-run chinook from the Upper Willamette and Clackamas Rivers (Myers et al. 1998).

The Molalla River is located 50 Km from the mouth of the Willamette River above Willamette Falls. Surveys in 1940 and 1941 recorded 882 and 993 spring-run chinook salmon present (Parkhurst et al. 1950). Craig and Townsend (1946) collected a number of juveniles moving downstream from the Molalla River. Mattson (1948) estimated the run size to be 500 in 1947. ODFW (1995) determined that the naturally spawning population in the Molalla River was extinct, although efforts are currently underway to reestablish natural production.

Surveys in Abiqua Creek, a tributary to the Pudding River, which flows into the Molalla River, in 1940 observed 250 spring-run chinook salmon (Parkhurst et al. 1950). ODFW (1995) determined that the naturally spawning population in Abiqua Creek was extinct.

A small run of spring chinook salmon historically existed in the Calapooia River. Parkhurst et al. (1950) reported that the run size in 1941 was approximately 200 adults, while Mattson (1948) estimated the run at 30 adults in 1947. ODFW (1995) considered the run in the Calapooia to be extinct, with limited future production potential.

Fall chinook are not indigenous to the Willamette Basin above Willamette Falls. However, fall chinook have been introduced into the areas above the Falls. These fish were not included in the listed chinook ESU. Releases of hatchery fall chinook was terminated in 1995 and the last adult returns generally complete in 1999. The abundance of fall chinook at the Falls has been approximately 2,000 to 3,000 fish in recent years. The returns of fall chinook in future years should decrease since no hatchery fish have been released recently.

3.2.2 Steelhead

No estimates of abundance prior to the 1960's are available for the winter steelhead ESU. Recent run size of winter steelhead can be estimated from counts at Willamette Falls, dams, and redd observations. Summer steelhead have been introduced into the Upper Willamette River and return primarily to the North and South Santiam, McKenzie, and Middle Fork rivers. Winter steelhead in the Clackamas Subbasin (below Willamette Falls) are part of the Lower Columbia ESU.

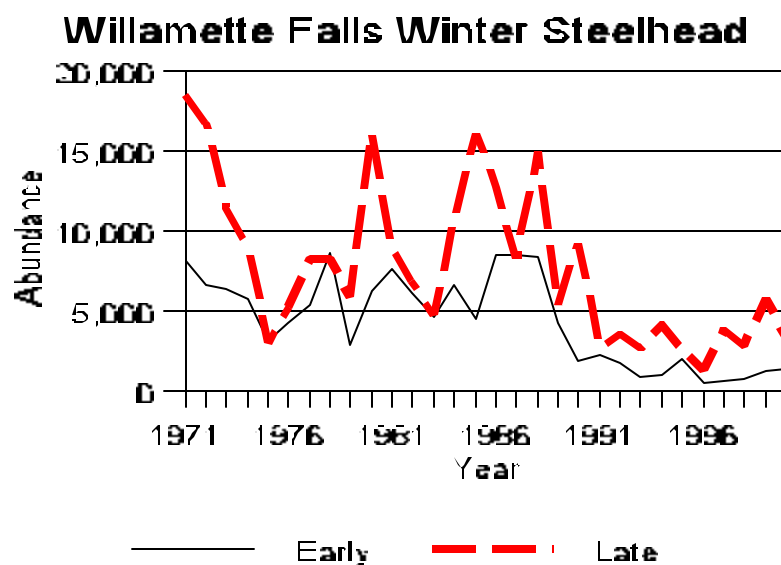


Figure 17. Counts of winter steelhead at Willamette Falls. The early run is from November 1- February 15 and represents primarily non-indigenous Big Creek stock. The late run is from February 16- May 15 and represents primarily indigenous stock.

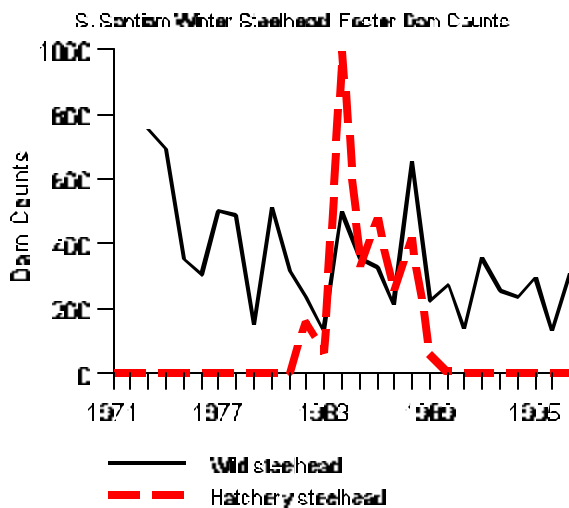


Figure 19. Counts of winter steelhead at Foster Dam on the S. Santiam River. Data from Chicote (1998).

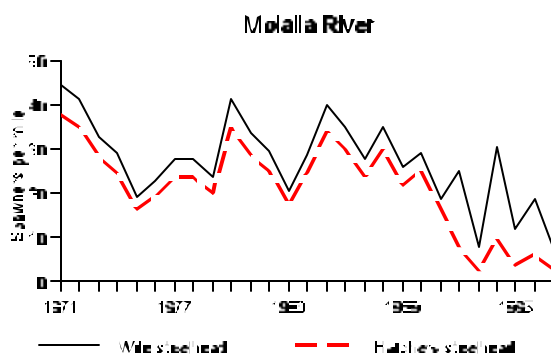


Figure 20. Counts of winter steelhead in the Molalla River. Data from Chicote (1998).

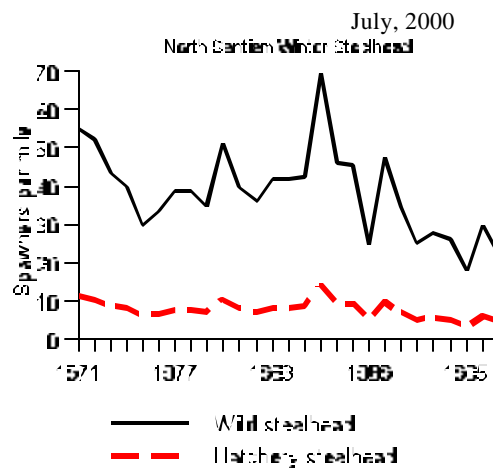


Figure 18. Counts of winter steelhead in the North Santiam River. Data from Chilcote (1998).

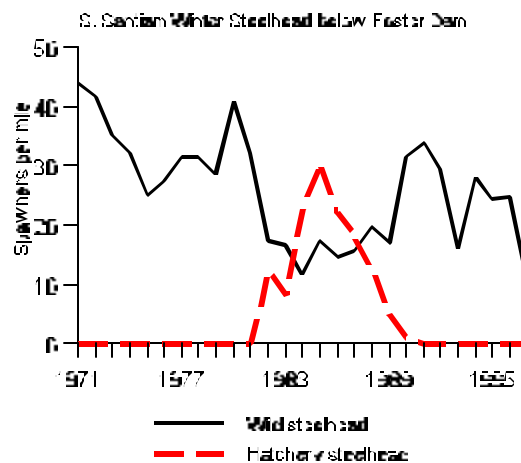


Figure 21. Counts of winter steelhead below Foster Dam on the South Santiam River. Data from Chilcote (1998).

July, 2000

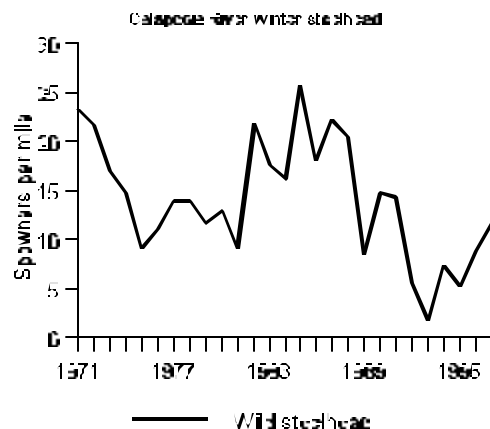


Figure 23. Counts of winter steelhead in the Calapooia River. Data from Chilcote (1998).

Summer steelhead are not indigenous to the Willamette Basin above Willamette Falls. Summer steelhead were introduced above the Falls. These fish are not included as part of the listed steelhead

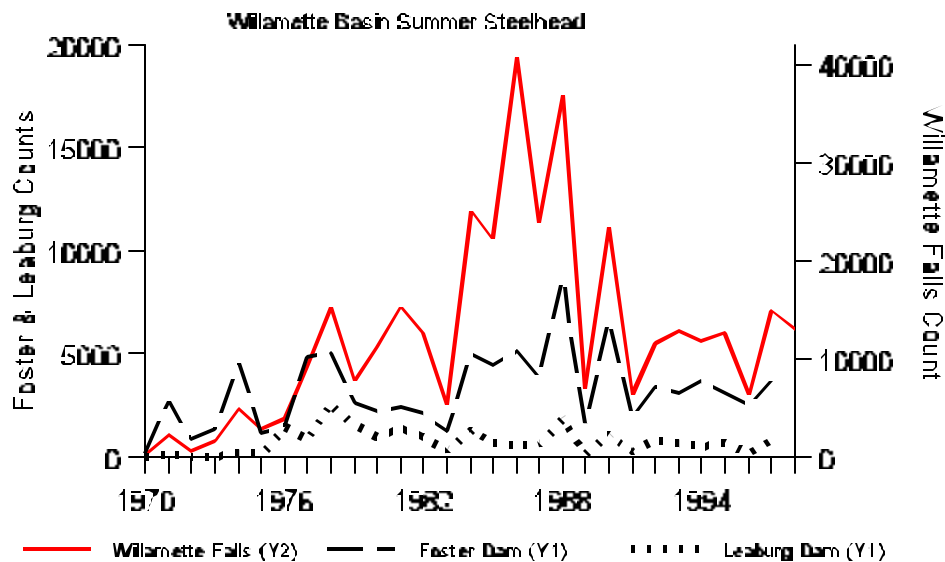


Figure 22. Counts of summer steelhead at Willamette Falls, Foster Dam on the South Santiam River, and Leaburg Dam on the McKenzie River. Data from ODFW (1998)(Foster report at Falls).

ESU. The return of summer steelhead has been relatively large since the early 1980's (Figure 19, Figure 22). This production is supported primarily by the release of hatchery fish.

4 Environmental Baseline

The “environmental baseline” for Biological Opinions is defined in the ESA section 7 implementing regulations as:

“the past and present impacts of all Federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process.” (50 CFR §402.02).

Summary of Environmental Baseline

- All four of the “H’s” have significantly impacted listed spring chinook and winter steelhead and their habitat in the Willamette Basin.
- The construction of flood control dams has eliminated a substantial proportion of the historic habitat.
- The quantity and quality of the remaining spawning and rearing habitat has been significantly degraded.

The ESA Section 7 Consultation Handbook (USFWS and NMFS 1998) further states that the environmental baseline is:

“an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem within the action area. The environmental baseline is a “snapshot” of a species’ health at a specified point in time.”

These definitions illustrate that the environmental baseline is more than the current condition of physical habitat within the action area. The environmental baseline is the progression of the physical, chemical, and biological conditions over time within the action area that has resulted in the current status of the listed species. Past and present human and natural factors influence these conditions, causing them to change over time. In this consultation, the environmental baseline is described in terms of how these conditions have changed in response to human activities over the last 150 years. This section thus includes descriptions of past conditions, based on available scientific information, as well as how these conditions have been modified or transformed by human activities into current conditions.

4.1 Artificial Propagation

Artificial propagation programs started in the late 1800's in many rivers in efforts to increase the runs of salmon and steelhead in the Willamette River Basin. Hatchery programs have likely adversely affected the indigenous stocks from introduction of out of basin stocks, genetic introgression, and mining the natural population for broodstock. Myers et al. (1998) reported that from 1902 to 1994 over 706 million chinook salmon have been released into the Upper Willamette Basin. Approximately 29% of this total were chinook brought in from areas outside of the Willamette Basin.

Current hatchery programs in the Willamette Basin were initiated to mitigate for the substantial habitat loss and degradation associated with the construction and operation Federal and non-Federal dams in

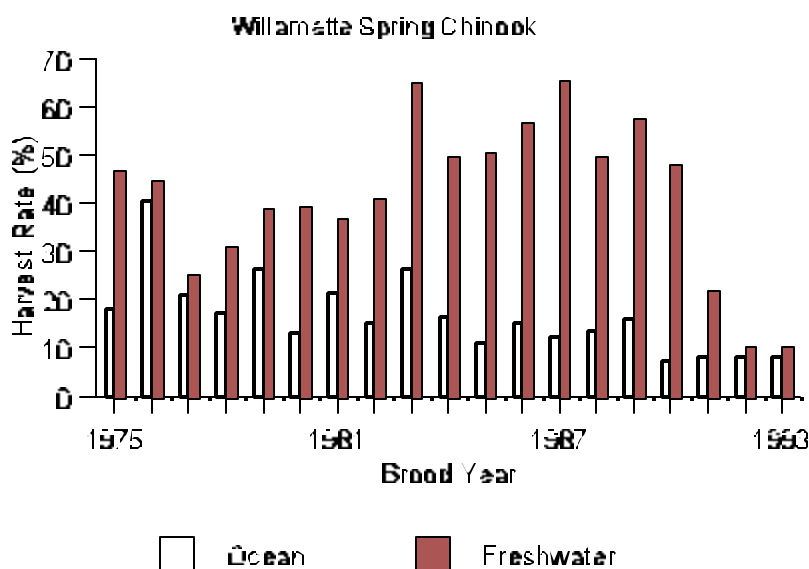


Figure 24. Harvest rates of Willamette River spring chinook in ocean and freshwater fisheries. Brood years 1991-93 are incomplete for all age groups. Freshwater harvest rates do not include fisheries in the tributaries of the Willamette River.

the Willamette Basin (see section 4.4). Most of the current hatchery programs have been in existence since the 1950's. The run of spring chinook is currently predominately hatchery fish with naturally produced fish estimated to be approximately 10% of the annual return (ODFW 2000). The continuous high number of hatchery fish on the spawning grounds is suspected to have resulted in the homogenization of the remaining indigenous stocks in the Upper Willamette (Nicholas et al. 1995). Hatchery practices may have also contributed to the change in spawn timing of spring chinook. Historically, spring chinook spawned from July through late October. However, current spawning occurs primarily in late September (Lindsay et al. 1997, 1998, 1999). The presence of hatchery chinook has also sustained high harvest rates in freshwater fisheries which has also impacted natural-origin spring chinook (Figure 24).

Emphasis on artificial propagation to mitigate the impacts of habitat loss and degradation has further accelerated the decline in naturally spawning populations due to harvest effects on the less numerous natural-origin fish. Furthermore, emphasis on maximizing artificial production during the first half of the 1900s led to the mining of naturally-produced spawners, delayed or blocked passage to historical spawning grounds by hatchery weirs, and the exchange of eggs among hatcheries in the Upper Willamette River Basin to fill capacity. Much of the between-population genetic diversity was probably eliminated through egg exchanges among hatcheries.

Hatchery fish have also affected native winter steelhead in the Willamette Basin. Summer steelhead have been introduced into the Upper Willamette River. However, it is unknown how successfully these fish have produced natural offspring. Winter steelhead from the Lower Columbia River (Big Creek stock) have also been introduced in the Upper Willamette Basin. These fish have an earlier run timing. However some introgression of this stock is likely to have occurred in the native winter steelhead populations. In recent years the hatchery program for winter steelhead in the Upper Willamette River ESU has been terminated.

4.2 Fisheries

Salmon and steelhead in the Willamette River have supported many commercial and recreational fisheries which contributed to their decline. In the past, harvest of natural-origin spring chinook and winter steelhead was permitted. However, recently fisheries management has focused on protecting natural-origin stocks and more conservative fishing regimes have been implemented.

In the past, cumulative harvest rates of spring chinook in ocean and freshwater fisheries has been high (Figure 24). Until recently spring chinook were subjected to relatively intense commercial and recreation fisheries in the lower Columbia and Willamette rivers that were directed primarily at the abundant hatchery-origin fish. Terminal area exploitation rates have been on the order of 40-50% in past years. Fishery objectives in the Willamette River have also changed to emphasize the protection of

natural-origin fish. The State of Oregon is developing a Fisheries Management and Evaluation Plan under NMFS' 4(d) Rule for the management of chinook fisheries in the Willamette River. This management plan will specify the harvest regime for spring chinook and must be approved by NMFS for coverage under the ESA. Oregon has already been mass marking chinook salmon in recent years and intends to manage terminal area recreational fisheries in the near future requiring the release of all unmarked, naturally-produced fish. The marked fish will fully recruit to the terminal fishery in the year 2002. Once the marked fish are fully recruited to the fishery, it is expected the Lower Willamette fishery can be managed for selective harvest of hatchery fish while limiting mortality of natural-origin fish to 5 to 10% of the run (Lindsay et al. 1999b).

Because of their ocean migration distribution, Upper Willamette River spring chinook benefit relatively little from the Pacific Salmon Treaty (PST) agreement (NMFS 1999 PST biop). Upper Willamette chinook are a far north migrating stock and so are caught primarily in Southeast Alaska (SEAK) and North Coast British Columbia (NCBC) fisheries. Because they are an early returning spring stock, they tend to be missed by more southerly ocean fisheries off West Coast Vancouver Island and the Washington coast. The total exploitation rates for the 1982-1992 brood years averaged 62%. The average exploitation rates under the PST conditions are unchanged. The average exploitation rates in the SEAK and NCBC fisheries under base conditions was 17% with virtually all of the remaining harvest occurring in the terminal area fisheries.

Winter steelhead are caught primarily in freshwater recreational fisheries in the Lower Columbia and Willamette rivers. Prior to the early 1990's, natural-origin winter steelhead could be harvested. Since then, all returning hatchery steelhead have been externally marked and fishing regulations require the release of all unmarked adult steelhead. Total mortality from fishing has been reduced from previous levels. Currently, mortality of listed winter steelhead is likely to be less than 5% of the returning run; the mortality associated with catch and release fishing. Since 1997, Oregon has further reduced fishing impacts to juvenile winter steelhead in the Upper Willamette ESU by not allowing the retention of unmarked trout, eliminating put and take hatchery trout fisheries in streams, and prohibiting the use of bait while angling during the general trout season. This changes will likely reduce the mortality of juvenile steelhead. In addition, the hatchery steelhead program using Big Creek stock (non-ESU) has been eliminated to reduce incidental fishing mortality on listed steelhead and genetic introgression of this stock into the indigenous steelhead populations.

Impacts to listed species from fisheries has been reduced substantially since 1996. However, the benefits of these changes has not yet been realized. It is expected that listed populations will increase in abundance if fishing has been a limiting factor.

4.3 Development and Operation of Flood Control Dams

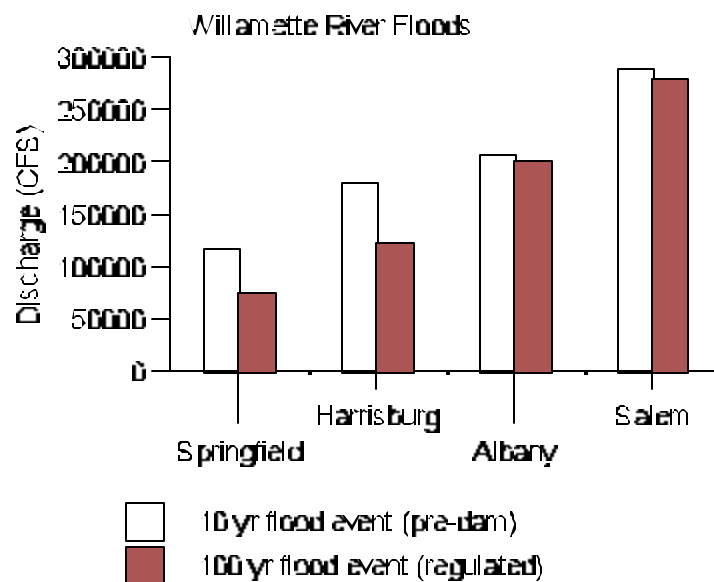


Figure 25. Comparison of the magnitude and frequency of floods before dam development and under current dam regulation at four locations on the mainstem Willamette River. Flood events that, on average, recurred every 10 years during pre-dam development, now recur at a lower magnitude every 100 years (Data from Benner and Sedell 1997).

The construction and operation of the Federal flood control dams in the Willamette Basin has significantly influenced the status of listed species and their habitat. Because the flood control dams have affected the distribution, life history, and habitat of listed species in such a significant manner, it is separated from the general “Habitat Alteration” section discussed below.

From 1952 to 1968, the Corps constructed 13 dams on all of the major east side tributary streams to the Willamette River above the Falls, blocking over 400 miles of stream habitat previously accessible to spring chinook salmon and winter steelhead (ODFW and WDFW 1999). Most of the dams do not have fish passage or the facilities are inadequate for unimpeded passage upstream and downstream.

Mattson (1948) conducted an evaluation of the percentage of the spring chinook run in the Willamette Basin that utilized areas above where the Corps dams were proposed to be built. Mattson estimated that over 48% of the spring chinook run in 1947 would be eliminated from the proposed dams. Subsequently, the dams were built and eliminated most of the historic habitat for spring chinook. Mattson estimated 100% of the spring chinook run to the Middle Fork Willamette would be eliminated

from the construction of Dexter and Fall Creek dams (Figure 15; no fish passage). In the McKenzie Subbasin, the dams were constructed in the headwaters and blocked access to only 2% of the estimated run to the McKenzie. This is likely the reason why the McKenzie Subbasin still supports relatively high production of chinook. However, the importance of the South Fork McKenzie River for spring chinook production, which was blocked by the construction of Cougar Dam, was not fully recognized by Mattson (1948). USFWS (1959) estimated a loss of 4,000 adult spring chinook from Cougar Dam. In the South Santiam, Mattson estimated 85% of the run to this subbasin would be eliminated by the proposed dams. However, Foster Dam (Figure 13; inadequate fish passage) was constructed below the lowermost dam Mattson evaluated and consequently the habitat lost would likely exceed 85%. In the North Santiam Subbasin, the construction of Big Cliff and Detroit Dams (Figure 12; no fish passage) blocked access to more than 70% of the habitat used by spring chinook. In the Clackamas Subbasin, Cazadero Dam blocked upstream passage from 1917 to 1939. Subsequently, fish passage facilities were developed to allow adequate upstream passage. The spring chinook population remained at relatively low levels until Clackamas Hatchery started releasing spring chinook in the mid 1970's. The run subsequently increased to the current levels.

In addition to the elimination of the majority of anadromous fish habitat, the operation of the dams has significantly affected the life history, distribution, and survival of the remaining natural-origin populations of spring chinook. The occurrence and magnitude of floods events has been significantly altered in the Willamette Basin (Figure 25). This change has implications to nutrient input, stream habitat dynamics, and the survival of juvenile fish. Current flow regimes in the Willamette Basin are counter to the natural regimes observed historically. Winter and spring water releases from the dams are warmer and of lower discharge, which has accelerated egg development and fish emerge earlier than what occurred historically. Summer flows are higher and cooler than historically. In the fall, flows are relatively high because the dams are being drawn down in preparation for the next years winter run-off into the reservoirs.

NMFS is currently in consultation with the Corps on the operation of their 13 flood control dams in the Willamette Basin. It is likely there will be some modifications to the operation of the dams to improve the survival of listed spring chinook and winter steelhead and the condition of their existing habitat.

Mitigation hatcheries were built to offset the substantial habitat losses resulting from dam construction and, as a result, 85%-95% of the production in the basin is now hatchery origin fish (see section 4.1). Given the extensive network of dams in the basin, extensive habitat degradation, and past harvest rates, it is likely that most, if not all, of the remaining populations would have been eliminated had it not been for the hatchery programs.

4.4 Habitat Alteration

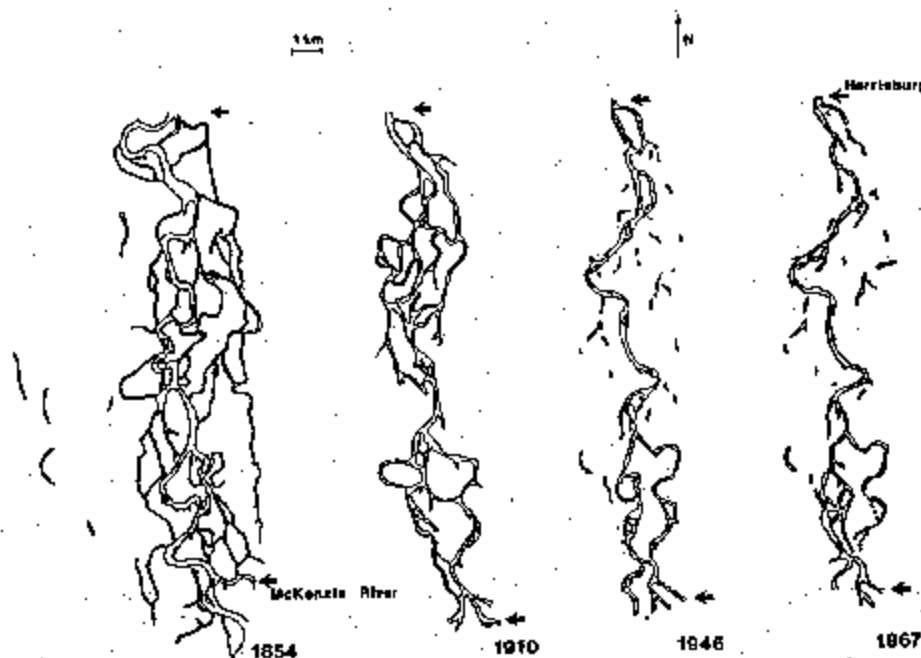


Figure 26. Example of the changes in channel morphology of the Willamette River from 1854 to 1967 (From Sedell and Froggatt 1984).

In general, human influences associated with forestry, farming, grazing, road construction, mining, and urbanization have all contributed to the decline of the listed species and their habitat. The combined effect of multitude of habitat degradations often poses the greatest risk and greatest challenge to species recovery because they are often the result of multiple dispersed actions, each of which must be addressed. Additionally, habitat degradations by their nature can only be remedied over time as the affected systems slowly recover their properly functioning condition.

As discussed in section 4.3, a significant majority of the historic habitat has been eliminated by dams. The remaining habitat available for anadromous fish occurs primarily in the lowland areas of the Willamette Valley. Most of the valley floor is privately owned (PNERC 1998) and has been converted to agricultural use, with Douglas fir and Oregon white oak stands present in less-developed areas (Figure 27). Irrigation is commonly employed, and stream flows, especially in the southern portion of this region, can be significantly affected. Agricultural and livestock practices contribute to soil erosion and fertilizer/manure deposition into stream systems.

Channel alterations (bank hardening, channel downcutting, dredging, and isolating sloughs with cut-off dams) have resulted in the simplification of the once highly braided river system (Figure 26). Sedell and Froggatt (1984) reported from 1870 to 1950, over 65,000 snags and streamside trees were pulled and cut up along the mainstem Willamette River. This removal of woody debris represented an average of

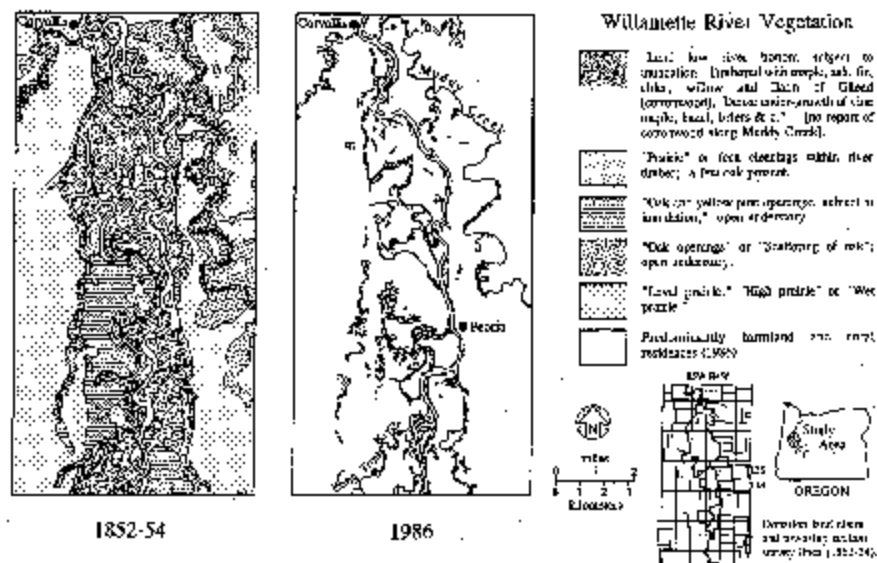


Figure 27. Changes in vegetation along the Willamette River from 1852 to 1986 (From Benner and Sedell 1997).

550 snags per river kilometer. The average size of these snags ranged between 30-60 m in length and 0.5-2 m in diameter. The cottonwoods were the largest and were often 50 m long and 2 m in diameter.

Water quality is impacted by agricultural and urban activities. Many water quality problems are exacerbated by low water flows and high temperatures during the summer. Pulp and paper mill discharges of dioxin into the Columbia and Willamette Rivers were cited as another water quality concern, although this situation has been much more serious in the past (Wentz et al. 1998). Agricultural and urban operations have led to increases in pesticides, nutrients, trace elements, and organic compounds in the streams where anadromous fish reside. In addition, a six mile stretch of the Lower Willamette River near Portland has been proposed as a federal Superfund site by the Environmental Protection Agency.

In the early 1920s water tests by local and state agencies indicated that much of the lower Willamette River was heavily polluted by both municipal and industrial (primarily pulp and paper industries) wastes. A 1929 survey concluded that during summer low flow conditions, the dissolved oxygen levels in the lower Willamette River dipped to levels at or below 0.5 PPM (Gleeson, 1972). Furthermore, these conditions continued for an additional 30 years before there was any detectable improvement in water conditions (Gleeson, 1972).

Historically, spring chinook populations existed in the smaller subbasins of the Willamette, such as the

Molalla, Pudding, Thomas Creek, Crabtree Creek, Wiley Creek, Coast Fork, and Row River (Nicholas et al. 1995). Habitat loss and degradation are the primary factors leading to the extinction of these natural-origin populations and currently limits the reestablishment chinook in these areas (Nicholas et al. 1995). However, in the future with substantially reduced harvest rates and improved artificial propagation techniques, reintroduction into these habitats might be feasible.

Due to the significant changes in habitat quality discussed above, the fish community has changed dramatically in the Willamette Basin. An USGS study of water quality in the Willamette Basin (Wentz et al. 1998) found fish community conditions that were characteristic of degraded and polluted systems and ranked among the poorest 25 percent of streams sampled in the U.S. by the National Water Quality Assessment program. At one of the agricultural sites sampled in this study (Molalla Subbasin), 99% of the fish were non-native, pollution tolerant species and 61% of the fish exhibited external anomalies (Wentz et al. 1998).

4.5 Human Population

The expansion of the human population in the Willamette Valley can directly affect most, if not all, of the factors affecting listed species and their habitat. Since the colonization of the Columbia River Basin by Euro-Americans, the Willamette Valley has been a significant location for settlement. Prior to 1850, approximately 95% of the 13,000 people that lived in Oregon were in the Willamette Valley (PNERC 1998). Since the 1860's Oregon's population has increased exponentially. As of 1990, approximately 70% of Oregon's 2.7 million people resided in the Willamette Valley (PNERC 1998). The human population in the Willamette Valley is projected to continue to increase exponentially in the near future. This has significant direct and indirect implications to listed species and the quantity and quality of their current habitat.

4.6 Natural Conditions

Changes in the abundance of salmon populations are affected substantially by variations in freshwater and marine environments. For example, large scale changes in climatic regimes, such as El Niño, likely affect changes in ocean productivity. Much of the Pacific coast was subject to a series of very dry years during the first part of the decade which adversely affected some the populations. In more recent years, severe flooding has adversely affected other stocks. The low fish runs observed recently may still be attributed to the 100 year flood events observed in the basin in 1996.

Chinook salmon are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation likely also contributes to significant natural mortality, although the levels of predation are largely unknown. In general, chinook are prey for pelagic fishes, birds, and

marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebounding of seal and sea lion populations, following their protection under the Marine Mammal Protection Act of 1972, has resulted in substantial mortality for salmonids. In recent years, for example, sea lions have learned to target spring chinook and steelhead at Willamette Falls and have gone so far as to climb into the fish ladder where they can easily consume migrating anadromous fish. In the Columbia River estuary, colonies of terns and cormorants have increased significantly in abundance because of human related factors. It has been estimated that these colonies consume millions of the smolts that enter the estuary.

A key factor that has substantially affected many west coast salmon stocks has been the general pattern of long-term decline in ocean productivity. The mechanism whereby stocks are affected is not well understood. The pattern of response to these changing ocean conditions has differed between stocks, presumably due to differences in their timing and distribution. It is presumed that ocean survival is driven largely by events between ocean entry and recruitment to a sub-adult life stage. One indicator of early ocean survival can be computed as a ratio of coded wire tags (CWT) recoveries at age 2 relative to the number of CWTs released from that brood year. Overall, there has been a declining trend in early ocean survival since the 1970's with extremely low survivals observed in recent years.

Recent evidence suggests that marine survival of salmon species fluctuates in response to 20-30 year long periods of either above or below average survival that is driven by long-term cycles of climatic conditions and ocean productivity (Cramer 1999; Figure 27) . This has been referred to as the Pacific Decadal Oscillation (PDO). It is apparent that ocean conditions and resulting productivity affecting many of northwest salmon populations have been in a low phase of the cycle for some time. Smolt-to-adult return rates provide another measure of survival and the effect of ocean conditions on salmon stocks. The smolt-to-adult survival rates for Puget Sound chinook stocks, for example, dropped sharply beginning with the 1979 broods to less than half of what they were during the 1974-1977 brood years (Cramer 1999). The variation in ocean conditions has been an important contributor to the decline of many stocks. However, the survival and recovery of these species depends on the ability of these species to persist through periods of low ocean survival when stocks may depend on better quality freshwater habitat and lower relative harvest rates.

4.7 Expected Future Performance

The Upper Willamette River Basin has undergone substantial anthropogenic changes in the last 150 years. Loss of access to the majority of the historical spring-run spawning grounds due to dam construction, channelization of the mainstem Willamette River, and degradation in river water quality (especially in the Willamette Valley) has lead to the decline in anadromous fish populations in the basin.

Although the amount of available spawning habitat was reduced by the construction of dams, the

remaining habitat is largely unsuitable due to the thermal and hydrological characteristics of the water discharged from the base of the dam. Under existing conditions it may be unreasonable to expect the reestablishment of significant self-sustaining populations to North or South Santiam and Middle Fork Willamette River Basins. Specific fish passage and habitat degradation factors may have led to the extirpation of spring-run populations in the Molalla, Pudding, and Calapooia Rivers. Presently, these same factors appear to be limiting the probability of reestablishing self-sustaining populations.

Naturally spawning late-run winter steelhead exist in a number of major and minor tributaries to the Willamette River. Populations exist in the North and South Santiam River Basins, with a remnant population in the Calapooia River. Additionally, there is a population in the Molalla River, although this may be descended from hatchery fish introduced from the North Santiam Hatchery. Small spawning aggregations of unknown origin also exist in the Pudding, and Tualatin Rivers. The loss of or degradation in their spawning, rearing, and holding habitat similarly affects steelhead and spring-run chinook salmon.

Production within the existing habitat is likely to increase from that observed in the early 1990s. It is thought that the Pacific Northwest is shifting into a wet climatic regime which will likely increase production of fish in the freshwater and ocean environments (LaNina; Figure 28). Recently, ocean conditions have been less favorable for anadromous fish survival due to El Nino effects. The stream environment is also improving (higher streamflows, etc) from the drought conditions that existed in the late 1980's and early 1990's.

5 Effects of the Actions

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined at 50 CFR §402.02. Appendix B details how NMFS evaluates artificial propagation programs to determine if listed ESUs are jeopardized. This section of the Biological Opinion applies those standards in determining whether the proposed hatchery programs are likely to jeopardize the continued existence of the ESUs listed in Table 2. This analysis considers the direct, indirect, interrelated and interdependent effects of the proposed actions and compares them against the Environmental Baseline to determine if the proposed hatchery programs will reduce appreciably the likelihood of survival and recovery of these listed salmon and steelhead in the wild by reducing the reproduction, numbers or distribution of the listed ESU.

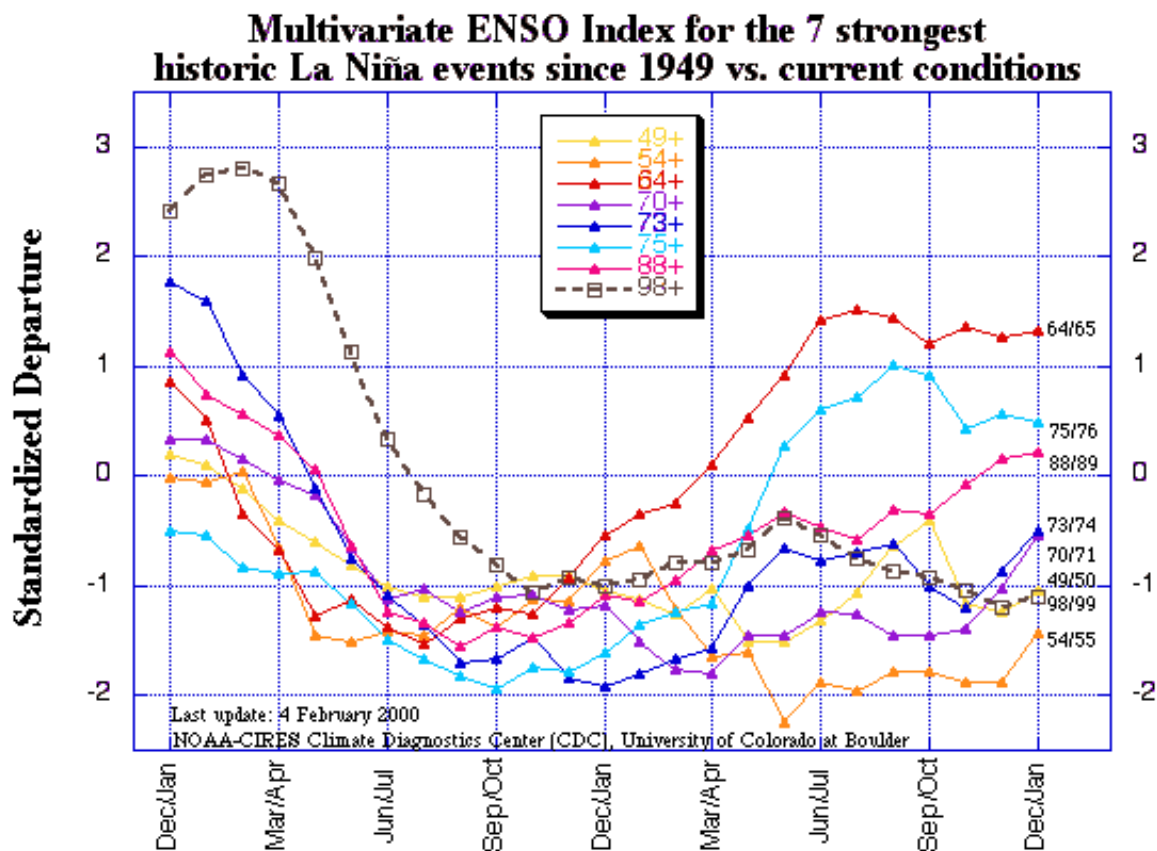


Figure 28. Comparison of current ocean conditions (98/99 series) versus the strongest LaNiña events since 1949. Generally, LaNiña regimes represent ocean conditions more favorable for anadromous fish survival off the coasts of California, Oregon, and Washington (NPPC 1999).

The NMFS has published a technical memorandum entitled “Viable Salmonid Populations and Recovery of ESUs” (McElhany et al. 2000) to help guide hatchery and harvest management decisions. This concept provides guidance in determining the health of salmonid populations based upon several biological parameters (abundance, productivity, spatial structure, and life history diversity).

The VSP concept is useful in that it provides a basis for evaluating artificial propagation in this consultation based on the status of the listed populations. VSP establishes critical and viable threshold levels for certain biological parameters. The critical thresholds generally represents a state where the population is at relatively low abundance or productivity. Management decisions must be very conservative in order to alleviate additional extinction risk to the population. At the viable threshold, the population is functioning properly and at self-sustaining abundance levels. Management decisions could be less conservative because the population is healthy and the risk of extinction is low. The thresholds for abundance depends upon the specific ESU and historic information on distribution and abundance. In general, if population abundance is less than 500-5,000 per generation, there is an increased risk of extinction. If the generation length was four years, the annual spawner abundance at this critical level would be in the range of 125-1,250 fish. At viable levels, abundance would range from 5,000 to 10,000 fish per generation.

5.1 General Effects of Artificial Propagation Programs

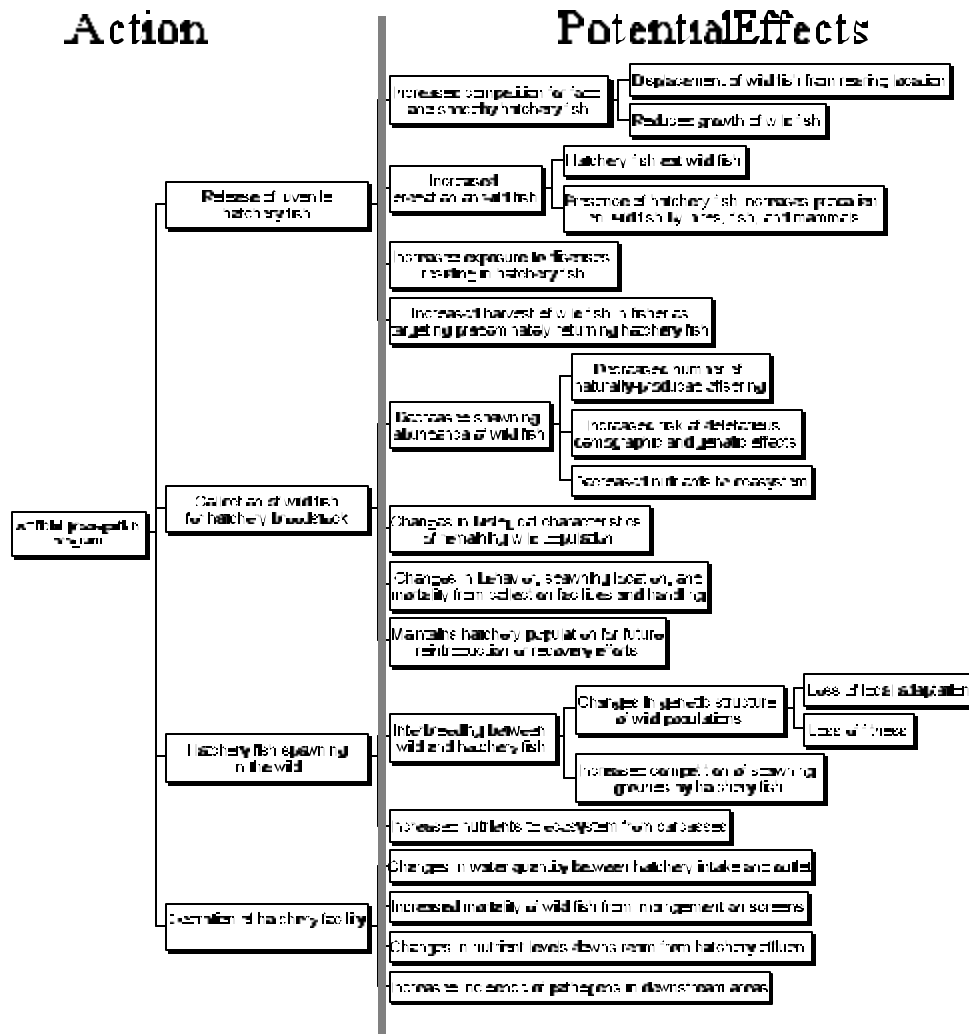


Figure 29. Diagram of the potential effects to listed fish from the operation of artificial propagation programs.

5.1.1 Broodstock Collection

Salmonid broodstock required for hatchery programs are typically collected from volitional returns to the hatchery or through use of a weir, or ladder-trap combination associated with a barrier, such as a dam. These devices can effectively block the upstream migration of returning adult fish, forcing them to

enter a trap and holding area. Trapped fish are counted, and either retained for use in the hatchery or released upstream of the weir or barrier to spawn naturally. Fish can also be released downstream to enhance sport fishing opportunities.

In the Willamette Basin, the majority of hatchery production is to mitigate for the loss of salmonid production associated with the construction of dams. In most cases, broodstock are collected at dam facilities, which are typically the uppermost point of distribution. Broodstock collection is required to fulfill mitigation obligations.

The potential adverse impacts to migrating listed adult salmon and steelhead from the use of weirs or traps to collect broodstock include (1) delays in upstream migration, (2) rejection of the weir or fishway structure, inducing spawning downstream of the trap (displaced spawning), (3) falling back downstream after passing upstream of the weir, (4) injury or death from attempts to jump the barrier and (5) induced stress from handling (Hevlin and Rainey 1993, Spence et al. 1996). Negative effects to listed fish may also include: physical harm that may result from capture and retention in the fish holding area within a weir or trap, or from snagging, netting or seining methods used for certain programs; harm that may result from delay in upstream migration, if the fish are reluctant to enter the trap, or as a result of capture and excessive holding durations; physical harm resulting from handling prior to release upstream; damage or mortality resulting from impingement on the face of weirs, if fish released upstream of the weir attempt to drop back downstream; incidental, immediate mortality resulting from the above impacts; and increased susceptibility after release to displacement downstream by current and to predation, as the fish recover from handling. Most, if not all, of these impacts are due to the physical presence and operation of the weir or trap.

Many of the potential negative effects can be reduced through the proper design and operation of the weirs and traps (see Hevlin and Rainey 1993). The installation and operation of weirs and traps for broodstock collection are very dependant on water conditions at the trap site. High flows in the spring can delay the installation of a weir and can make the trap inoperable during periods of high flows. A weir or trap can potentially be operated in two modes: operate the trap continuously and collect up to 100% of the run, while passing those fish not needed for broodstock upstream to spawn naturally; or operate the weir for a number of days each week to collect broodstock, then operate the weir with the panels lowered or the trap open to provide unimpeded passage for the rest of the week. The mode of operation can be determined during the development of site-based broodstock collection protocols and can be adjusted based on in season escapement estimates and environmental factors.

By operating the weirs and traps as described above, the potential impacts of weir rejection, fall back and injury are reduced by allowing unimpeded passage for a period each week. To further reduce the impacts of weir or trap operation, trained hatchery personnel would be present at the facility to remove debris, prevent poaching and ensure safe and proper facility operation. To reduce delay and handling

stress all fish encountered during broodstock collection should be held for a minimal duration in the traps, generally less than 24 hours. Often it may be necessary to hold fish longer or remove them from the spawning run as the hatchery weir or trap is used to remove stray fish or adjust the ratio of natural to hatchery fish that are allowed to spawn naturally.

Other methods to collect adult broodstock for artificial production programs include the use of beach seines, hook and line, gillnets and collection while snorkeling. All these methods can adversely effect listed fish through physical injury, migrational delay, changes in holding and spawning behavior and increased susceptibility to predation and poaching. Some artificial production programs collect juveniles for their source of broodstock. Programs can collect developing eggs or fry by hydraulically sampling redds, or by capping redds to collect emerging juvenile fish (Young and Marlowe 1996, Shaklee et al. 1995, WDFW et al. 1995, WDFW 1998 [1196 permit application]). Seines, screw traps and hand nets can also be used to collect juveniles. Each of these methods can adversely effect listed fish through handling and harm to fish remaining in the river. Juveniles collected with these methods tend to be used for captive broodstock programs, reared to adults and spawned in a production facility with the resulting progeny being released to migrate naturally to the ocean (Hard et al. 1992, NMFS 1999 [captive prop standards] Young and Marlowe 1996, Shaklee et al. 1995, WDFW et al. 1995, WDFW 1998 [1196 permit application]). The collection of juveniles for broodstock eliminates the potential adverse effects of selection through artificial matings that can occur when using adults for broodstock (NRC 1996).

The removal of adults from the naturally-spawning population has potential adverse impacts, including numerical reduction of the natural population (mining), selection effects, genetic effects (described below) and removal of nutrients from upstream reaches (Spence et al. 1996, NRC 1996, Kapusinski 1997). Selection effects include the intentional and unintentional selection of broodstock based on run timing, age, morphology and sex ratio. Selection effects can potentially change population characteristics of the natural population as well as cause the hatchery-produced fish to diverge from the naturally-produced population (see genetic effects below).

In some basins wild spring chinook populations are not replacing themselves and are to the point where extinction of one or all of the extant runs appears likely without artificial production programs, and assisted by changes in hydroelectric dam operations, harvest activities, and competing land use actions. Risks to the donor wild populations, including numerical reduction and selection effects, are in some cases subordinate to the need to expeditiously implement the artificial production programs that will prevent extinction of the populations and the ESU. The operating agency can preserve remaining wild populations and address numerical reduction and selection effects through the implementation of one or more of the following measures:

- ! broodstock removals will be limited within the region through designation of "nonintervention"

- ! areas where artificial production programs will not be applied. The designation of "non-intervention" areas will prevent numerical reduction impacts to some of the region's populations;
- ! for those areas where supplementation and/or captive broodstock programs will be applied, the upstream escapement of a predetermined number of adults per population will be maintained as a minimum level for natural spawning;
- ! removal of adult broodstock at traps for artificial production programs shall be random, and representative of the run-at-large with respect to migration timing, age class, morphology, and sex ratio. Selection effects on that portion of each fish population allowed to spawn naturally will be minimized through these measures;
- ! natural production should be allowed to continue concurrent with the artificial production programs by providing passage for or by releasing to spawn naturally, a minimum number of adult fish into natural spawning areas within the basin; and
- ! surplus and spawned-out salmon carcasses, should be considered for instream distribution to increase nutrients into natural spawning areas, where appropriate.

Kapuscinski and Miller (1993) proposed guidelines for broodstock collection to address genetic impacts that can result from broodstock selection effects. These include setting priorities for choice of donor population based on three criteria. The criteria for identifying the best donor population as compared to the target population that will be supplemented are based on the greatest similarity of the two populations in terms of (1) genetic lineage, (2) life-history patterns, and (3) ecology of the originating environment. For restoration where the target population is extirpated the best choice is a neighboring population from an environment meeting the three criteria above. When augmenting a population that is at a depressed level, the best choice for broodstock is to use that population.

5.1.2 Genetics

A defining characteristic of anadromous salmonids is a very high fidelity of returning adults to their natal streams. The ability of anadromous salmonids to home with great accuracy and maintain high fidelity to natal streams has encouraged development of locally adapted genetic characteristics which allow the fish to use specific habitats.

The genetic risks to naturally-produced populations from hatchery propagation include loss of fitness, reduction in the genetic variability (diversity) within and between populations, genetic drift, selection, and domestication (Hard et al. 1992, Cuenco et al. 1993, NRC 1996, and Waples 1996).

The loss of genetic diversity among populations is the reduction in the difference in quantity, variety and combinations of alleles among populations (Busack and Currens 1995). The loss of genetic diversity among populations is caused by the introduction of genes from outside the population (e.g. from hatchery releases), at rates greater than what would occur naturally. This introduction can cause the

loss of genetic uniqueness of the natural population with a concurrent reduction in performance (fitness) of the fish. Excessive gene flow into a population can reduce the fitness of individual populations through outbreeding depression. Salmon populations adapt to the local environment and this adaptation is reflected in the frequency of specific alleles that improve survival in that environment. When gene flow occurs, alleles that may have developed in a different environment are introduced into the population and these new alleles may not benefit survival. Another source of outbreeding depression is the loss of combinations of alleles called coadapted complexes. Gene flow can introduce new alleles that can replace alleles in the coadaptive complexes leading to a reduction in performance (Busack and Currens 1995). Outbreeding depression from gene flow occurs when eggs and fish are transferred between populations and/or when out of basin hatchery populations are released to spawn with the local population.

Evidence exists for local adaptation of salmonid populations, but empirical data on outbreeding depression in fish that involves anything but extremely distantly related populations is lacking (Busack and Currens 1995). Pacific Northwest hatchery programs historically fostered the loss of genetic diversity among populations through routine transfer of eggs and fish from different populations between hatcheries to meet production needs. Release of hatchery fish into watersheds outside the original distribution of the introduced fish has also resulted in gene flow above natural levels, reducing diversity between populations. Research based primarily on findings in the Kalama River, Washington for summer-run steelhead has suggested that interbreeding between non-indigenous Skamania hatchery stock steelhead (a highly selected, inbred stock) and native natural-origin fish may negatively affect the genetic diversity and long term reproductive success of natural-origin steelhead (Leider et al. 1990; Hulett et al. 1996). Non-indigenous stock hatchery and native natural-origin steelhead crosses may be less effective at producing adult off-spring in the natural environment compared to natural-origin fish (Chilcote et al. 1986; 1997). Qualifying the risks of hatchery introgression to natural-origin fish, Campton (1995) noted the need to distinguish the biological effects of hatcheries and hatchery fish from indirect and biologically independent effects of human factors related to management. His review of the scientific literature for steelhead indicated that most genetic effects detected to date appear to be caused by hatchery or fish management practices such as stock transfers and mixed stock fisheries on hatchery and natural-origin fish, and not by biological factors intrinsic to hatcheries or hatchery fish (Campton 1995). Loss of among population genetic diversity as a result of these types of hatchery practices has been documented for western trout, where unique populations have been lost through hybridization with introduced rainbow trout (Behnke 1992). Phelps et al. (1994) found evidence for introgression of non-native hatchery steelhead stock into a number of natural populations within the southwest Washington region. However, in other areas where hatchery production has been extensive, native steelhead genotypes have been shown to persist (Phelps et al. 1994).

The risk of loss of genetic variability among populations, and the potential for and consequences of outbreeding depression, can be minimized through application of the following measures:

1) hatchery programs should propagate and release only indigenous fish populations; 2) the transfers of donor stock for reintroduction should be limited to avoid the situation that one or few stocks within an ESU predominate; 3) hatchery populations should be acclimated to the watershed where the fish are planted to ensure that propagated fish retain a high fidelity to the targeted stream; 4) local adaptation should be fostered by using returning spawners rather than the transferred donor population as broodstock for restoration programs; 5) natural populations, representing significant proportions of the existing total abundance and diversity of an ESU, should be maintained without hatchery intervention; and, 6) all salmonids produced in hatchery programs should be visually marked to allow for monitoring and evaluation of straying and natural spawning contribution of adult returns.

NMFS conducted a scientific workshop in 1995 which focused on the biological consequences of artificially elevated levels of straying into natural salmonid populations (Grant 1997). A key question addressed in the workshop was how much gene flow can occur above natural levels and still remain compatible with long-term conservation of local adaptations and diversity among populations. A value of 5% gene flow is much higher than what generally occurs between natural populations and non-local populations and would quickly lead to replacement of not only neutral genes, but locally-adapted ones as well, based on what is known about selection in other animals (Grant 1997). NMFS notes that gene flow is expected to be much less than the percentage of out of basin strays. Based on the current science, NMFS has included a jeopardy standard for hatchery stray rates between ESUs to be managed such that less than 5% of a naturally spawning population consists of hatchery fish from another ESU (See Appendix B). Furthermore, whenever feasible, the percentage or number of non-endemic adult strays into a particular population should be as low as possible to minimize genetic introgression.

The standard for stray rates of hatchery fish from within an ESU, should be managed such that not more than 5% - 30% of the naturally spawning population consist of hatchery fish from within the ESU (See Appendix B). Within this range, stray rates should be managed based on similarity of the hatchery population to the receiving natural population. For example, if the hatchery population is derived from the receiving natural population and gets regular infusion of natural fish in its broodstock, then strays rates can be at the higher end of this range (although lower rates are preferred). Conversely, if the hatchery population is derived from a population other than the receiving population, then strays should be managed to the lower end of the range. Also, if the hatchery population is derived from the receiving natural population, but has been isolated, without regular infusion of natural fish into the broodstock, then it should be managed to the lower end of the 5% - 30% range.

Hatchery programs implemented for the specific purpose of enhancing the listed, naturally spawning population may by their very design, provide for a greater proportion of hatchery fish in the naturally spawning population to reduce the demographic risks of extinction. The desired proportion of hatchery fish in the spawning population must be specifically detailed in the associated HGMP for such a

program. In practice this proportion (or range) may be varied to experiment with the different approaches.

Artificial propagation also has the potential to increase the risk of loss of within population genetic diversity caused by inbreeding depression, genetic drift, or domestication selection. Loss of within population genetic diversity (variability) is the reduction in quantity, variety and combinations of alleles in a population (Busack and Currens 1995). Quantity is defined as the proportion of an allele in the population and variety is the number of different kinds of alleles in the population. There are generally two ways that within population genetic diversity can change, the first is random genetic drift and other is through inbreeding. Random genetic drift occurs because the progeny of one generation represents a sample of the quantity and variety of alleles in the parent population. Since the next generation is a sample and not a copy of the parent generation, rare alleles could be lost, especially in small populations where the rare allele is less likely to be represented in the next generation (Busack and Currens 1995).

The other mechanism of change is inbreeding, which is the breeding of related individuals. Inbreeding may not lead directly to changes in the quantity and variety of alleles in a population but inbreeding increases individual and population homozygosity. The homozygosity contributes to changes in the frequency of phenotypes in the population which are then acted upon by the environment. If the environment is selective towards specific phenotypes then the frequency of alleles in the population can change (Busack and Currens 1995). Waldman and McKinnon (1993) observed that genetic changes in a population from inbreeding depression can result from the expression of homozygous genotypes for rare, harmful alleles that are normally hidden in the population of heterozygotes. These genetic changes can also come from lower performance of the population (fitness) since heterozygotes tend to perform better than homozygotes.

It is important to note that empirical evidence for inbreeding depression or substantial loss of genetic variability in any natural or hatchery populations of Pacific salmon or steelhead is lacking (Hard and Hershberger 1995, quoted in Myers et al. 1998). Genetic baselines derived from allozyme data for discrete populations were only recently developed (late 1980s), and no comparisons between “pristine” and existing hatchery population allele frequencies are possible.

In hatchery programs the effective population size can be used to identified potential sources of random genetic drift. Small effective population size in hatchery programs can contribute to genetic drift by the use of small numbers of broodstock, using more females than males (or the alternative), pooling gametes, changing the age structure and allowing progeny of some matings to have greater survival than allowed others (Gharrett and Shirley 1985, Simon et al. 1986, and Withler 1988 cited in Busack and Currens 1995, Waples 1991, Campton 1995). Hatchery stocks have been found to have less genetic diversity than wild populations (Waples et al. 1990) indicating the potential for random genetic drift in hatcheries. The loss of genetic diversity within a hatchery population could be due to a genetic

bottleneck, which occurs when only a very small number of fish are used for broodstock. Potential, negative effects of artificial propagation on within population diversity may be indicated by changes in morphology (e.g. Bugert et al 1992) or behavior of salmonids (e.g. Berijikian 1995). Busack and Currens (1995) observed that it would be difficult to totally control random loss of within population genetic diversity in hatchery populations, but by controlling the broodstock number, sex ratios and age structure loss could be minimized.

The other major hazard of the artificial propagation of salmon is domestication, which is the changes in quantity, variety and combination of alleles within a captive population or between a captive population and its source population in the wild that are the result of selection in an artificial environment (Busack and Currens 1995). Domestication is also defined as selection for traits that favor survival in an artificial environment and reduce survival in natural environments (NMFS 1999). Domestication can result from putting fish into an artificial environment for all or part of their lives. The artificial environment imposes different selection pressures on the fish than would the natural environment. The concern is that domestication effects will decrease the performance of hatchery fish and their descendants in the wild. Busack and Currens (1995) identified three types of domestication selection (1) intentional or artificial selection, (2) biased sampling during some stage of culture and (3) unintentional selection.

Reisenbichler and Rubin (1999) cite five studies indicating that hatchery programs for steelhead and stream-type chinook (i.e. programs holding fish in the hatchery for one year or longer) genetically change the population and thereby reduce survival for natural rearing. The authors report that substantial genetic change in fitness results from traditional artificial production of anadromous salmonids held in captivity for one quarter or more of their life. Bugert et al. (1992) documented morphological and behavioral changes in hatchery spring chinook salmon released as yearlings relative to natural adults, including younger age, smaller size, and reduced fecundity at adult return. Leider et al. (1990) reported diminished survival and natural reproductive success compared to native natural-origin steelhead for the progeny of non-native hatchery steelhead in the lower Columbia River region. Poorer survival for naturally produced offspring of hatchery fish could have been due to long term artificial and domestication selection in the hatchery steelhead population, as well as maladaptation of the non-indigenous hatchery stock in the recipient stream (Leider et al. 1990). Chilcote (1997) reported a strong negative correlation between the proportion of naturally spawning hatchery steelhead and stock productivity, through an examination of spawner-recruit relationships for 26 Oregon steelhead populations. Berijikian (1995) reported that natural-origin steelhead fry survived predation by prickly sculpins (*Cottus asper*) significantly better than size-matched off-spring of locally-derived hatchery steelhead which were reared under similar conditions. Alteration of the innate predator avoidance ability through domestication was suggested by the results of this study. However, Joyce et al. (1998) reported that an Alaskan spring chinook stock under domestication for four generations were not significantly different from offspring of wild spawners in the ability to avoid predation. The domesticated and natural-origin chinook groups tested also showed similar growth and survival rates in

freshwater performance trials.

Artificial selection is the attempt to change the population to meet management needs, such as selecting for time of return or spawning time. The concern is that hatchery fish selected to perform well in a hatchery environment tend not to perform well when released into the wild, this is due to the difference between the hatchery and the wild populations. Potential impacts to the wild population occurs when the hatchery fish spawns in the wild and the resulting performance of the wild population is reduced due to outbreeding depression (Busack and Currens 1995). Domestication due to biased sampling generally occurs from error and can occur during any stage of hatchery operation. The selection of broodstock is a common source of biased sampling. In general, broodstock selection should be random but bias occurs when selection is based on particular traits. Genetic changes due to unintentional selection can be caused by the hatchery environment which allows more fish to survive than compared to the natural environment.

There are fish culture practices and management strategies that can be applied to minimize levels of inbreeding and/or selection for characteristics that are divergent from the natural population.

Measures to minimize the genetic differences between hatchery and natural fish:

- ! Adults used for broodstock can be randomly selected from throughout the natural population migration, to provide an unbiased sample of the natural population with respect to run timing, size, age, sex ratio, and other traits identified as important for long term fitness.
- ! Ensure that returning adults used as broodstock by a hatchery continually incorporate natural-origin fish over the duration of the program to reduce the likelihood for divergence of the hatchery population from the natural population.
- ! Limit the duration of a supplementation program to a maximum of three salmon generations (approximately 12 years) to minimize the likelihood of divergence between hatchery broodstocks and target natural stocks.
- ! Employ appropriate spawning protocols to avoid problems with inbreeding, genetic drift and selective breeding in the hatchery (e.g. Simon et al. 1986, Allendorf and Ryman 1987, Gall 1993). Methods include collection of broodstock proportionally across the breadth of the natural return, randomizing matings with respect to size and phenotypic traits, application of at least 1:1 male to female mating schemes (Kapusinski and Miller 1993), and avoidance of intentional selection for any life history or morphological trait.
- ! Use spawning protocols that equalize as much as possible the contributions of all parents to the next breeding generation.
- ! Use only natural fish for broodstock in the hatchery each year to reduce the level of domestication.
- ! Set the minimum broodstock collection objectives to allow for the spawning of the number of adults needed to minimize the loss of some alleles and the fixation of others (Kapusinski and

Miller 1993).

- ! Set minimum escapements for natural spawners and maximum broodstock collection levels to allow for at least 50% of escaping fish to spawn naturally each year, to help maintain the genetic diversity of the donor natural population.
- ! Use hatchery methods that mimic the natural environment to the extent feasible (e.g. use of substrate during incubation, exposure to ambient river water temperature regimes and structure in the rearing ponds).
- ! Limit the duration of rearing in the hatchery by releasing at early life-stages to minimize the level of intervention into the natural salmonid life cycle, minimizing the potential for domestication.

Measures to minimize the effects of interbreeding between hatchery and natural stocks:

- ! Release fewer or no hatchery fish.
- ! Release hatchery fish only at the hatchery or at locations where they are unlikely to interbreed with natural fish when returning as adults.
- ! Advance or retard time of spawning for hatchery fish, to minimize overlap in spawning time between hatchery and natural fish.
- ! Acclimate hatchery fish prior to release to improve homing precision.
- ! Acclimate and release hatchery fish at locations where adults returns can be harvested at high rates (harvest augmentation programs), locations away from natural production areas and sites where returning adults can be sorted and removed from the spawning population.

More detailed discussions on the measures to implement these strategies can be found in Reisenbichler (1997), Reisenbichler and McIntyre (1986), Nelson and Soule (1987), Goodman (1990), Hindar et al. (1991) and Waples (1991) among others.

5.1.3 Competition/ Density-Dependent Effects

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g. food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Adverse effects of competition may result from direct interactions, whereby a hatchery-origin fish interferes with the accessibility of limited resources to wild fish, or through indirect means, as in when utilization of a limited resource by hatchery fish reduces the amount available for wild fish (SIWG 1984). Specific hazards associated with adverse competitive effects of hatchery salmonids on listed wild salmonids may include food resource competition, competition for spawning sites, and redd superimposition. In an assessment of the potential ecological effects of hatchery fish production on wild salmonids, the Species Interaction Work Group (SIWG 1984) categorized species combinations as to whether there is a high, low, or unknown risk that competition by hatchery fish will have a significant negative impact on

productivity of wild salmonids in freshwater and nearshore marine areas:

Table 2. Risk of hatchery salmonid species competition on wild salmonid species in freshwater areas (SIWG 1984).

Hatchery Species	Wild Species					
	Steel head	Pink	Chum	Sockeye	Coho	Chinook
Steel head	H	L	L	L	H	H
Pink	L	L	L	L	L	L
Chum	L	L	L	L	L	L
Sockeye	L	L	L	L	L	L
Coho	H	L	L	L	H	H
Chinook	H	L	L	L	H	H

Note: "H" = High risk; "L" = Low risk; and "U" = Unknown risk of a significant impact occurring

Table 3. Risk of hatchery salmonid species competition on wild salmonid species in nearshore marine areas (SIWG 1984).

Hatchery Species	Wild Species					
	Steelhead	Pink	Chum	Sockeye	Coho	Chinook
Steelhead	H	U	U	L	U	U
Pink	U	H	H	U	U	U
Chum	U	H	H	U	U	U
Sockeye	L	U	U	H	U	U
Coho	U	U	U	U	H	U
Chinook	U	U	U	U	U	H

Note: “H” = High risk; “L” = Low risk; and “U” = Unknown risk of a significant impact occurring.

Adult fish

It is apparent that salmonids have evolved a variety of strategies to partition available resources between species that are indigenous to a particular watershed. The addition of homing or straying adult hatchery-origin fish can perturb these mechanisms and impact the productivity of wild stocks. For adult salmonids, impacts from hatchery/wild fish competition in freshwater are assumed to be greatest in the spawning areas where competition for redd sites and redd superimposition may be concerns (USFWS 1994). Adult salmonids originating from hatcheries can also compete with natural-origin fish of the same species for mates, leading to an increased potential for outbreeding depression, to the detriment of the natural-origin fish. Hatchery-origin adult salmonids may home to, or stray into, natural production areas during natural-origin fish spawning or egg incubation periods, posing an elevated competitive and behavioral modification risk. Returning or straying hatchery fish may compete for spawning gravel, displace natural-origin spawners from preferred, advantageous spawning areas, or adversely affect listed salmonid survival through redd superimposition. Superimposition of redds by similar-timed or later spawners disturbs or removes previously deposited eggs from the gravel, and has been identified as an important source of natural salmon mortality in some areas (Bakkala 1970).

Recent studies suggest that hatchery-origin fish may be less effective in competing for spawning sites than natural-origin fish of the same species, possibly indicating the effects of domestication selection in the hatchery environment (Fleming and Gross 1993; Berejikian et al. 1997). These studies were based on comparisons of natural-origin salmonid adults and captive-brood origin hatchery fish. Hatchery-origin salmonid adults returning to spawn after a period of rearing in the wild may exhibit different competitive effectiveness levels. The risk of straying by hatchery-produced species may be minimized through acclimation of the fish to their stream of origin, or desired stream of return. Homing fidelity may be improved through the use of locally adapted stocks, and by rearing of the fish for an extended duration (e.g. eyed egg to smolt) in the “home” stream prior to release or transfer to a marine area net-pen site for further rearing. The risk of redd superimposition can be minimized through high removal rates of the hatchery-origin fish, and by propagation and release of only indigenous species and stocks. Indigenous-origin hatchery adults that are not removed upon return may be assumed to still carry traits that foster temporal and spatial resource partitioning with naturally spawning fish populations (see SIWG 1984). The risk of redd disturbance may therefore be minimal with escapement of indigenous-origin hatchery fish, if the home stream has the physical characteristics (e.g. stream flow, usable channel width) that will allow such partitioning at the time of spawning.

Juvenile fish

For salmonids rearing in freshwater, food and space are the resources in demand, and thus are the

focus of inter- and intra-specific competition (SIWG 1984). Newly released hatchery smolts may compete with natural-origin fish for food and space in areas where they interact during downstream migration. Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, of equal or greater size, and (if hatchery fish are released as non-migrants) the hatchery fish have taken up residency before naturally produced fry emerge from redds. Release of large numbers of hatchery pre-smolts in a small area is believed to have greater potential for competitive effects because of the extended period of interaction between hatchery fish and natural fish. In particular, hatchery programs directed at fry and non-migrant fingerling releases will produce fish that compete for food and space with natural-origin salmonids for longer durations, if the hatchery fish are planted within, or disperse into, areas where natural-origin fish are present. A negative change in growth and condition of natural-origin fish through a change in their diet or feeding habits could occur following the release of hatchery salmonids. Any competitive impacts likely diminish as hatchery-produced fish disperse, but resource competition may continue to occur at some unknown, but lower level as natural-origin juvenile salmon and any commingled hatchery juveniles emigrate seaward. Hatchery-origin smolts and sub-adults can also compete with natural-origin fish in estuarine and marine areas, leading to negative impacts on natural-origin fish in areas where preferred food is limiting. Steward and Bjornn (1990) concluded that hatchery fish kept in the hatchery for extended periods before release as smolts (e.g. yearling salmon) may have different food and habitat preferences than natural-origin fish, and that hatchery fish will be unlikely to out-compete natural-origin fish. Interactions with juvenile hatchery-origin salmonids may lead to behavioral changes in listed natural salmonids that are detrimental to productivity and survival.

Hatchery fish might alter natural-origin salmon habitat use and behavioral patterns, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter wild salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Steward and Bjornn 1990; Hillman and Mullan 1989). In a review of the potential adverse effects of hatchery releases on natural-origin salmonids, Steward and Bjornn (1990) indicated that it was indeterminate from the literature whether wild parr face significant risk of displacement by introduced hatchery fish, as a wide range of outcomes from hatchery-wild fish interactions has been reported. The potential for negative effects on the behavior, and hence survival, of natural-origin fish as a result of hatchery fish releases depends on the degree of spatial and temporal overlap in occurrence of hatchery and natural-origin fish. The relative size of affected natural-origin fish when compared to hatchery fish, as well as the abundance of hatchery fish encountered, also will determine the degree to which natural-origin fish are displaced (Steward and Bjornn 1990). Actual effects on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

En masse hatchery salmon smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or

premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported displacement of juvenile natural-origin rainbow trout from discrete sections of streams by hatchery steelhead released into an upper Yakima River tributary, but no large scale displacements of trout were detected. Small scale displacements and agonistic interactions that were observed between hatchery steelhead and natural-origin trout resulted from the larger size of hatchery steelhead, which behaviorally dominated most contests. They noted that these behavioral interactions between hatchery-reared steelhead did not appear to have significantly impacted the trout populations examined, however, and that the population abundance of natural-origin salmonids did not appear to have been negatively affected by releases of hatchery steelhead.

Competition between hatchery and natural-origin salmonids in freshwater may only be of high risk for coho, chinook, steelhead, and sockeye, since pink and chum salmon do not rear for extended periods in freshwater (SIWG 1984). Studies indicate that hatchery coho salmon have the potential to adversely affect certain wild salmonid species through competition. Information suggests that juvenile coho salmon are behaviorally dominant in agonistic encounters with juveniles of other stream-rearing Pacific Northwest salmonid species, including chinook salmon, steelhead (*O. mykiss*), and cutthroat trout (*O. clarki*), and with natural-origin coho (e.g. Stein et al 1972; Allee 1974; Swain and Riddell 1990; Taylor 1991). Dominant salmonids tend to capture the most energetically profitable stream positions (Fausch 1984, Metcalfe et al. 1986), providing them with a potential survival advantage over subordinate fish. However, where interspecific populations have evolved sympatrically, chinook salmon and steelhead have evolved slight differences in habitat use patterns that minimize their interactions with coho salmon (Nilsson 1967, Lister and Genoe 1970, Taylor 1991). Along with the habitat differences exhibited by coho and steelhead, they also show differences in foraging behavior. Peterson (1966) and Johnston (1967) reported that juvenile coho are surface oriented and feed primarily on drifting and flying insects, while steelhead are bottom oriented and feed largely on benthic insects.

SIWG (1984) acknowledged that the risk of adverse competitive interactions in marine waters is difficult to assess, because of a lack of data collected at times when hatchery fish and natural-origin fish likely interact, and because competition depends on a variety of specific circumstances associated with hatchery-wild fish interaction, including location, fish size, and food availability. In marine waters, the main limiting resource for natural-origin fish that could be affected through competition posed by hatchery-origin fish is food. The early marine life stage, when natural-origin fish have recently entered the estuary and populations are concentrated in a relatively small area, may create short term instances where food is in short supply, and growth and survival declines as a result (SIWG 1984). This period is viewed as of special concern regarding food resource competition posed by hatchery-origin chum and pink salmon to natural-origin chum and pink salmon populations (Cooney et al. 1978; Simenstad et al. 1980; Bax 1983). The degree to which food is limiting after the early marine portion of a wild fish's life depends upon the density of prey species. This does not discount limitations posed on natural-origin

fish in more seaward areas as a result of competition by hatchery-origin fish, as data are available that suggests that marine survival rates for salmon are density dependent, and thus possibly a reflection of the amount of food available (SIWG 1984).

In general, hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile natural-origin fish in freshwater (Steward and Bjornn 1990). Measures to minimize the risk of adverse competitive interactions may therefore include release of hatchery smolts that are physiologically ready to migrate, as they should quickly emigrate seaward of spawning and rearing areas. Hatchery fish can be reared to sufficient size such that smoltification occurs within nearly the entire population, which reduces retention time in the streams after release (Bugert et al. 1991). Rearing on parent river water, or acclimation for several weeks to parent river water, also contributes to the smoltification process and reduced retention time in the streams. Other risk minimization measures include application of hatchery fish timing and area of release criteria designed to limit the amount of ecological interactions occurring between hatchery and naturally produced fish. For example, hatchery smolts can be released after the major seaward emigration period for wild salmonid populations to minimize the risk of interaction that may lead to predation. Hatchery smolts could also be released in lower river areas, below upstream areas used for stream-rearing young-of-the-year wild salmon fry.

5.1.4 Residualism

Most conventional artificial propagation programs hatch artificially spawned eggs and rear the resulting juveniles to pre-smolt or smolt stage. The smolts are released into rivers and streams with the anticipation that they will soon migrate to the ocean. In many cases, some portion of the hatchery-produced juveniles “residualize”, or become residents of the receiving water for an extended period of a year or more. The general effects of hatchery-produced fish on natural fish, as described by Steward and Bjornn (1990) may be exacerbated if a substantial portion of the hatchery-produced juvenile salmonids residualize.

As discussed in sections V. A. 6 and 7, above, particular concern has been identified when resident trout and hatchery steelhead, released into spawning and nursery areas, fail to migrate (residualize), and potentially prey upon or compete with listed salmon and steelhead fry. Steelhead residualism has been found to vary greatly, but is thought to typically average between 5% and 10% of the number of fish released (USFWS 1994). Releasing hatchery steelhead smolts that are prepared to migrate and timing the release to occur during high flow conditions may minimize impacts to listed fish from steelhead programs.

Coho salmon in most situations, do not have the same potential to residualize as steelhead, but approximately 6% of the coho planted as parr residualized in the receiving stream in the Clearwater

River drainage for a year after release (Johnson and Sprague 1996). Coho salmon parr stocked in 1995, were observed two years after release in snorkel surveys and screw traps (BIA 1998) and about 2,000 age two coho smolts were counted at Snake River mainstem dams (FPC in BIA 1998). So far there does not appear to be any residualism of coho salmon smolts released into the Yakima and Methow rivers (T. Scribner, YIN, pers. comm.).

Ocean-type chinook salmon, like the fall chinook of the Snake River and mid-Columbia generally begin migration towards salt water soon after emergence, however some may spend up to one year before undertaking the smolt migration (Healey 1991). In the Snake River, Conner et al (1992) report a small percentage of hatchery-produced fall chinook smolts spend more than a year as residents in the Snake River before smolting. Although most stream-type chinook juveniles become smolts in the spring one year after emergence, some may spend a second year in fresh water, particularly slower-growing individuals. This effect may be related to cooler water temperatures in more northern or higher elevation waters (Healey 1991).

In fish hatcheries, an attempt is made to standardize the life history of fish produced. Spring/summer chinook eggs are spawned in August and September with a target of producing smolts approximately 20 months later in April. Fall chinook are spawned in November with a target of producing smolts by the following spring, in about 6 months. Coho typically are spawned in November and December and smolts are released 15 to 18 months later. Summer steelhead are typically spawned in March through May and smolts are released in 11 or 12 months. As noted above, the freshwater portion of the life history of most anadromous salmonids is quite variable in nature. While most ocean-type chinook migrate within a few months of emergence, some remain in freshwater for a full year and while most stream-type chinook and coho migrate in the spring, one year after they emerge from the gravel, some will stay a second or even a third year (Groot and Margolis 1991). Steelhead have the most variable fresh water life history of all the anadromous salmonids, typically spending one to three years in fresh water, but with some individuals spending up to 7 years in fresh water before spending 1 to 3 years in the ocean (Busby et al. 1996). As with chinook, the slower growing steelhead or those living in cooler waters may exhibit extended freshwater residence.

The variability in life history exhibited by naturally produced anadromous salmonids probably has some adaptive and survival advantages. By allowing slow-growing fish extra time in freshwater this strategy may ensure smolts that are large enough to improve migration survival. That not all spawners are the same age allows transfer of genetic material among age classes of a population and protects against loss of an entire spawning year to a single natural catastrophe. Adaptability to cooler water or less productive water by extending freshwater residency may allow anadromous fish to occupy a greater variety of habitats. The current conventional wisdom on hatchery management would support the standardization of life history and the rearing protocols which produce smolts on a single, uniform, schedule, but this practice may be intentionally selecting away from the genetic heritage of the fish. As

more hatchery programs are converted to conservation purposes using locally adapted and listed broodstocks, and as artificial propagation practices include more natural rearing environments, hatchery managers may have to accommodate variable life histories in production protocols.

In the case of artificial propagation programs for unlisted steelhead, particularly the programs that rear composite, domesticated and out-of-basin stocks, hatchery managers should continue to develop rearing and release protocols that reduce residualism and improve the smolting response, including acclimation, volitional release and growth schedules that produce healthy smolts that are of the proper size and stage of development at the appropriate time to initiate the smolt migration.

Acclimation ponds and volitional release strategies are currently the subject of active research in the Columbia River Basin. It is unclear at this time whether or not acclimating and volitionally releasing steelhead smolts can significantly reduce the proportion of residualized steelhead in all cases. WDFW appears to be able to significantly reduce the number of residualized steelhead released by using a combination of acclimation, volitional release strategies, and active pond management whereby remaining steelhead are not released when sampling indicates the majority of remaining fish in pond are males. This action is taken because preliminary WDFW research indicates that the majority of residualized steelhead are males. ODFW monitoring has not confirmed WDFW results (USFWS 1994). The ODFW saw no reduction in steelhead residualism rates in 1993 from acclimated fish in comparison to direct stream releases; however, they did not employ active pond management strategies (USFWS 1994). Providing juvenile holding facilities and acclimation ponds at sites with large release numbers may provide benefits even if residualism is not reduced. As an example, by having juvenile holding facilities at the release sites, the physiological condition of the smolts can be considered, volitional release strategies could be employed, and local environmental conditions could be used as indicators of when to release fish so they immediately begin migration.

The level of smolt development exhibited by yearling spring/summer chinook has been shown to be an important factor affecting migratory behavior. Developmentally advanced yearling chinook migrate from Dworshak National Fish Hatchery to Lower Granite Dam significantly faster than less developed counterparts (Giorgi 1991; Smith et al. 1993). Current release strategies are influenced to a large extent by when transport vehicles are available and not necessarily when smolts are developmentally ready to migrate.

In the 1995-98 Biological Opinion, NMFS recommended that hatchery steelhead smolts be released at sizes between 170 and 220 mm total length (TL), approximately 163-212 mm fork length (FL), based primarily on the work of two IDFG researchers, Cannamela (1992, 1993) and Partridge (1985). The maximum size recommendation was based on reports of higher residualism among steelhead over 240 mm TL and higher predation rates by residual steelhead over 250 mm TL. New analysis by IDFG suggests that the 220 mm maximum size is less than the ideal size to release smolts (Rhine et al. 1997).

In several tests, Rhine reports that residual steelhead are significantly smaller than smolts. Of those steelhead smolts carrying PIT tags, 52.1% of fish released at 163-211 mm were detected at downstream dams, 66% of steelhead 212-250 mm TL were detected and 83.3% of steelhead greater than 250 mm TL were detected. Bigelow (1997) reported similar results in PIT tagged steelhead smolts released from Dworshak Hatchery. Over 70% of steelhead under 180 mm TL were not detected at downstream sites, while approximately 85% of smolts over 180 mm TL were detected.

This information suggests that release of juvenile steelhead less than 180 mm TL will contribute to residualism and the ideal release size may be larger than 220 mm TL. However, concern for both residualism and predation by very large smolts (over 250 mm TL) is still valid. Jonasson et al. (1996) reported predation on natural-origin juvenile steelhead by residual hatchery steelhead as small as 189 mm FL, but in general the larger residual fish tended more toward predation. Overall, Jonasson et al. (1996) reports a low level of piscivory by residuals less than 230-250 mm TL.

Based on this information the recommended steelhead smolt size range should be 180 mm to 250 mm TL. Further, if predation increases as size of fish released from hatcheries increases, then hatchery managers should avoid release of larger smolts in waters that support rearing fry of listed species. Hatchery managers should continue to evaluate the impacts of size at release on predation and residualism along with other measures to increase smolt success.

Smolts that residualize not only pose a potential threat to naturally produced salmonids, they have a lower probability of returning as adults and fulfilling the intended purpose of fishery enhancement or mitigation. Healthy hatchery-produced smolts that migrate to the ocean soon after release have a good chance to return as adults, while those that select an extended stream residence often do not survive (Steward and Bjornn 1990). If a high percentage of hatchery-produced smolts successfully return as adults, less production is required to meet mitigation or treaty trust responsibilities.

5.1.5 Predation

Risks to wild salmonids attributable to direct predation (direct consumption) or indirect predation (increases in predation by other predator species due to enhanced attraction) can result from hatchery salmonid releases in freshwater and estuarine areas. Hatchery-origin fish may prey upon juvenile wild salmonids at several stages of their life history. Newly released hatchery smolts have the potential to prey on wild fry and fingerlings that are encountered in freshwater during downstream migration, or if the hatchery fish residualize prior to migrating. Hatchery-origin smolts, sub-adults, and adults may also prey on natural-origin fish of susceptible sizes and life stages (smolt through sub-adult) in estuarine and marine areas where they commingle. Hatchery salmonids planted as non-migrant fry or fingerlings, and progeny of naturally spawning hatchery fish also have the potential to predate upon natural-origin salmonids in freshwater and marine areas where they co-occur. In general, natural-origin salmonid

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populations will be most vulnerable to predation when natural-origin populations are depressed and predator abundance is high, in small streams, where migration distances are long, and when environmental conditions favor high visibility. SIWG 1984 categorized species combinations as to whether there is a high, low, or unknown risk that direct predation by hatchery fish will have a significant negative impact on productivity of natural-origin salmonids as follows:

Table 4. Risk of hatchery salmonid species predation on natural-origin salmonid species in freshwater areas (SIWG 1984).

Hatchery Species	Wild Species					
	Steelhead	Pink	Chum	Sockeye	Coho	Chinook
Steelhead	U	H	H	H	U	U
Pink	L	L	L	L	L	L
Chum	L	L	L	L	L	L
Sockeye	L	L	L	L	L	L
Coho	U	H	H	H	U	U
Chinook	U	H	H	H	U	U

Note: "H" = High risk; "L" = Low risk; and "U" = Unknown risk of a significant impact occurring.

Table 5. Risk of hatchery salmonid species predation on natural-origin salmonid species in nearshore marine areas (SIWG 1984).

Hatchery Species	Wild Species					
	Steelhead	Pink	Chum	Sockeye	Coho	Chinook
Steelhead	U	H	H	H	U	U
Pink	L	L	L	L	L	L
Chum	L	L	L	L	L	L
Sockeye	L	L	L	L	L	L
Coho	U	H	H	H	U	U
Chinook	U	H	H	H	U	U

Note: "H" = High risk; "L" = Low risk; and "U" = Unknown risk of a significant impact occurring.

SIWG (1984) rated most risks associated with predation as unknown, because, although there is a high potential that hatchery and natural-origin species interact, due to a high probability of spatial and temporal overlap, there was relatively little literature documentation of predation interactions in either

freshwater or marine areas. Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to natural-origin fish (SIWG 1984). Salmonid predators are generally thought to prey on fish approximately 1/3 or less their length (USFWS 1994; NMFS 1999). Due to their location, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation by hatchery released fish. Their vulnerability is believed to be greatest as they emerge and decreases somewhat as they move into shallow, shoreline areas (USFWS 1994). Emigration out of hatchery release areas and foraging inefficiency of newly released hatchery smolts may minimize the degree of predation on salmonid fry (USFWS 1994).

Although considered as of “unknown” risk by SIWG (1984), data from hatchery salmonid migration studies on the Lewis River, Washington (Hawkins and Tipping 1998) provide evidence of hatchery coho yearling predation on salmonid fry in freshwater. The WDFW Lewis River study indicated low levels of hatchery steelhead smolt predation on salmonids. In a total sample of 153 out-migrating hatchery-origin steelhead smolts captured through seining in the Lewis River between April and June 24, 12 fish (7.8 %) were observed to have consumed juvenile salmonids (S. Hawkins, WDFW, pers. comm., July 1997). The juvenile salmonids contained in the steelhead stomachs appeared to be chinook fry. Sampling through this study indicated that no emergent naturally produced steelhead or trout fry (30-33 mm fl) were present during the first two months of sampling. Hawkins (1998) documented hatchery spring chinook yearling predation on natural-origin fall chinook juveniles in the Lewis River. A small number of spring chinook smolts were sampled (11), and remains of 10 salmonids were found (includes multiple observations of remains from some smolts). Predation on smaller chinook was found to be much higher in natural-origin smolts (coho and cutthroat predominately) than their hatchery counterparts. Steward and Bjornn (1990) referenced a report from California that estimated, through indirect calculations rather than actual field sampling methods, the potential for significant predation impacts by hatchery yearling chinook salmon on natural-origin chinook and steelhead fry. They also reference a study in British Columbia that reported no evidence of predation by hatchery chinook smolts on emigrating natural-origin chinook fry in the Nicola River. In addition, Bakkala (1970 - quoting Hunter 1959 and Pritchard 1936) reported that young coho salmon in some British Columbia streams averaged two to four chum fry per stomach sampled.

Predation by hatchery fish on natural-origin smolts or sub-adults is less likely to occur than predation on fry. Coho and chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish prey that is less than one-fifth of their length (Brodeur 1991). During early marine life, predation on natural-origin chinook, coho, and steelhead will likely be highest in situations where large, yearling-sized hatchery fish encounter sub-yearling fish or fry (SIWG 1984). Juanes (1994), in a survey of studies examining prey size selectivities of piscivorous fishes, showed a consistent pattern of selection for small-sized prey. Hargreaves and LeBrasseur (1986) reported that coho salmon smolts ranging in size from 100-120 mm fl selected for smaller chum salmon

fry (sizes selected 43-52 mm fl) from an available chum fry population including larger fish (available size range 43-63 mm fl). Ruggerone (1989; 1992) also found that coho smolts (size range 70-150 mm fl) selected for the smallest sockeye fry (28-34 mm fl) within a available prey population that included larger fish (28-44 mm fl). However, extensive stomach content analyses of coho salmon smolts collected through several studies in marine waters of Puget Sound, Washington do not substantiate any indication of significant predation upon juvenile salmonids (Simenstad and Kinney 1978). Similarly, Hood Canal, Nisqually Reach, and north Puget Sound data show little or no evidence of predation on juvenile salmonids by juvenile and immature chinook (Simenstad and Kinney 1978). In a recent literature review of chinook salmon food habits and feeding ecology in Pacific Northwest marine waters, Buckley (1999) concluded that cannibalism and intra-generic predation by chinook salmon are rare events. Likely reasons for apparent low predation rates on salmon juveniles, including chinook, by larger chinook and other marine predators are suggested by Cardwell and Fresh (1979). These reasons included: 1) due to rapid growth, fry are better able to elude predators and are accessible to a smaller proportion of predators due to size alone; 2) because fry have dispersed, they are present in low densities relative to other fish and invertebrate prey; and 3) there has either been learning or selection for some predator avoidance.

Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of emigrating natural-origin fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter natural-origin salmonid behavioral patterns, potentially influencing their vulnerability and susceptibility to predation (Hillman and Mullan 1989; USFWS 1994). Hatchery fish released into natural-origin fish production areas, or into migration areas during natural-origin fish emigration periods, may therefore pose an elevated, indirect predation risk to commingled listed fish. Alternatively, a mass of hatchery fish migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring listed natural-origin fish.

Hatchery effects through predation can be minimized through application of hatchery fish life stage, timing and area of release criteria designed to limit the amount of ecological interactions occurring between hatchery and naturally produced fish. Release of smolts only, and the application of criteria to ensure that a high proportion of the population is smolted and emigrates (e.g. volitional release practices, minimum coefficient of variation population size limits), can minimize the risk of predation. Smolts migrate seaward rapidly, limiting the duration of interaction between hatchery fish and natural-origin fish present within, and downstream of, release areas. Delaying hatchery fish releases until the major seaward emigration period for natural-origin salmonid populations has been completed can minimize the risk of interaction that may lead to predation. Hatchery smolts could also be released in lower river areas, below upstream areas used for stream-rearing young-of-the-year natural-origin salmon fry, reducing the likelihood for interaction between the hatchery and natural-origin fish.

5.1.6 Disease

Under certain conditions, hatchery effluent has the potential to transport fish pathogens out of the hatchery, where natural fish may be exposed to infection. Interactions between hatchery fish and natural fish in the environment may also result in the transmission of pathogens, if either the hatchery or natural fish are harboring a fish disease. This latter impact may occur in tributary areas where hatchery fish are planted and throughout migration corridors where hatchery and wild fish may interact. As the pathogens responsible for fish diseases are present in both hatchery and natural populations, there is some uncertainty associated with determining the source of the pathogen (Williams and Amend 1976, Hastein and Lindstad 1991). Hatchery-origin fish may have an increased risk of carrying fish disease pathogens because of relatively high rearing densities that increase stress and can lead to greater manifestation and spread of disease within the hatchery population. Under natural, low density conditions, most pathogens do not lead to a disease outbreak. When fish disease outbreaks do occur, they are often triggered by stressful hatchery rearing conditions, or by a deleterious change in the environment (Saunders 1991). Consequently, it is possible that the release of hatchery fish may lead to the loss of natural fish, if the hatchery fish are carrying a pathogen, if that pathogen is transferred to the natural fish, and if the transfer of the pathogen leads to a disease outbreak. Although hatchery populations can be considered to be reservoirs for disease pathogens because of their elevated exposure to high rearing densities and stress, there is little evidence to suggest that diseases are routinely transmitted from hatchery to natural-origin fish (Steward and Bjornn 1990).

To address concerns of potential disease transmission from hatchery salmonids to natural-origin fish in the Pacific Northwest, a number of fish health policies have been implemented. These policies established guidelines to ensure that fish health is monitored, sanitation practices are applied, and that hatchery fish are reared and released in healthy condition (PNFHPC 1989; IHOT 1995; WDFW 1996; WDFW and WWTIT 1998). Standard fish health monitoring under these policies include monthly and pre-release checks of propagated salmonid populations by a fish health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the populations. Specific reactive and proactive strategies for disease control and prevention are also included in the fish health policies. Significant fish mortality to unknown cause(s) are sampled for histopathological study. Incidence of viral pathogens in salmonid broodstocks are determined by sampling fish at spawning. Populations of particular concern may be sampled at the 100% level and may require segregation of eggs/progeny in early incubation or rearing. Compliance with NPDES permit provisions at hatcheries also acts to minimize the likelihood for disease epizootics and water quality impacts that may lead to increased natural-origin fish susceptibility to disease outbreaks. Full compliance with the regional fish health policies minimizes the risk for fish disease transfer.

5.1.7 Operation of Hatchery Facilities

Potential hazards to listed natural salmonids associated with the operation of hatchery facilities include hatchery facility failure (power or water loss leading to catastrophic fish losses), hatchery water intake impacts (de-watering of stream reaches, or fish entrainment, leading to mortality), hatchery water intake and outfall screening impacts (juvenile and adult entrainment), and effluent discharge effects (deterioration of downstream water quality). The actual effects of hatchery facility operations on listed fish depends on a number of factors bearing on the likelihood that the hatchery operation will contact juvenile and/or adult fish, and whether the program is appropriately operated to minimize the risk of adverse effects to listed fish within the watershed where the program is located.

Catastrophic loss of listed fish held or under propagation may occur as a result of de-watering or loss of water flow (due to power failure or screen fouling), flooding, or poor fish cultural practices. Methods that may be used to minimize the risk of catastrophic loss may include minimizing the time of holding of adult fish in traps where the fish may be at an elevated risk of injury or mortality in exposed stream areas due to flooding, de-watering, or poaching. The propagation of hatchery populations at more than one location may be used to spread the risk of loss, increasing the likelihood that the genome will be retained in the event of a catastrophic loss at one facility. Additional methods that may be used to minimize the likelihood of fish loss due to hatchery operations include: 1) on-site residence by hatchery personnel to allow rapid response to power or facility failures; 2) use of low pressure/low water level alarms for water supplies; 3) installation of back-up generators to respond to power loss; and, 4) training of all hatchery personnel in standard fish propagation and fish health maintenance methods.

Water withdrawals for hatcheries within spawning and rearing areas can diminish stream flow from points of intake to outflow. If great enough, such withdrawals can impede migration and affect spawning behavior of listed fish. Water withdrawals may also have impacts to other stream-dwelling organisms important as food for juvenile salmonids as well, including habitat loss and displacement, and physical injury at intake locations. Screening of hatchery intakes is critical to ensure that fish are not injured through impingement or permanently removed from streams. To prevent these outcomes, water rights issued for regional hatcheries are generally conditioned to prevent de-watering of salmon migration, rearing, or spawning areas. Hatcheries can also be designed to be non-consumptive. Water withdrawn for use can be returned after it flows through the facility near the point of withdrawal to minimize risks to natural-origin fish and other aquatic fauna. The risk of water withdrawal hazards can generally be minimized through compliance with water right permits. NMFS screening criteria for water withdrawal devices set forth conservative standards that help minimize the risk of damage to natural-origin salmonids and other aquatic fauna through screen entrainment (NMFS 1995, NMFS 1996).

Hatchery effluents may change water temperature, pH, suspended solids, ammonia, organic nitrogen, total phosphorus, and chemical oxygen demand in the receiving stream's mixing zone (Kendra 1991). The resultant level of impact or the precise effect of hatchery effluents on listed salmonids and other stream-dwelling organisms is usually unknown. The magnitude of the receiving water flow volume

relative to the discharge volumes from the hatcheries determines the level of impact to receiving waters. Any adverse effects of hatchery effluent are probably localized at the immediate point of discharge, as effluent is rapidly diluted in the receiving streams and rivers. The Clean Water Act requires hatcheries (i.e. “aquatic animal production facilities” as defined by the Environmental Protection Agency) to obtain a National Pollutant Discharge Elimination System (NPDES) permit for the discharge of hatchery effluent to surface waters. These permits are intended to protect aquatic life and public health and assure that every facility treats wastewater. The permits include site-specific discharge limits, monitoring and reporting requirements, and are subject to enforcement actions if the facility fails to comply with the provisions of their permit (EPA 1999). In addition, hatcheries within the Columbia River Basin operate under the policies and guidelines developed by the Integrated Hatchery Operations Team (IHOT 1995) to reduce the effects on listed fish from the operation of hatchery facilities. The risk of this hazard to listed fish may generally be minimized through compliance with applicable NPDES permit requirements and IHOT policies and guidelines.

5.1.8 Migration Corridor

The hatchery production ceiling called for in the Proposed Recovery Plan for Snake River chinook ESUs is approximately 197.4 million anadromous fish. Although releases occur throughout the year, approximately 80 percent occur from April through June. A significant portion of these releases do not survive to the Snake and Columbia River migration corridors. As an example, the historical passage index of hatchery fish released into the Snake River Basin surviving to Lower Granite Dam shows a ratio of .23 for spring/summer chinook salmon and .60 for steelhead; for hatchery releases in the Columbia River above McNary Dam the ratio is .185 for spring/summer chinook salmon, .477 for sub-yearling chinook salmon, .093 for steelhead, and .215 for coho salmon (FPC 1992). While the actual number of hatchery fish entering the Columbia River migration corridor is unknown, it is significantly less than the number of fish released from the hatcheries (Table 3). There are several reasons that not all juvenile salmonids that are produced or released in headwater areas do not survive to the main stem migration corridors. As discussed in Section 5.1.4, some number residualize and do not become smolts. Some number of fish that have survived in the relatively benign environment of the hatchery succumb to their inability to survive in the wild, shortly after release, as predators, transportation stress, and failure to adapt to life in the natural stream take a toll. Many of the releases migrate several hundred miles before they reach the first of the mainstem dams where they are counted. Even many of the naturally produced smolts may die due to predators and other hazards of the migration, which occurs during the spring freshet.

As noted above in section 5.1.5 on predation, the hypothesis that large numbers of hatchery-produced smolts have effects on lesser numbers of naturally-produced smolts in the migration corridor and ocean assumes that there is a limitation on the capacity of the migration corridor and ocean and that interaction between hatchery-produced and naturally produced smolts occurs.

Chapman (1986) estimated that the sustainable runs of chinook prior to settlement of the Columbia Basin by European immigrants were 7.5 to 8.9 million adult fish, based on back calculations from peak commercial catches. The NWPPC has adopted a range of 8 to 16 million adult anadromous salmonids, based on historical data, and the PFMC developed an estimate of 6.2 million based on habitat. (NPPC 1986, PFMC 1979). These estimates could generally be described as a long-term average run size of 10 million plus or minus 5 million fish.

In the 1990s, smolt-to-adult survival (SAR), measured from smolts leaving the mouth of the Columbia to adults returning has been about 1 percent. Approximately 100 million smolts (of all anadromous salmonid species) are estimated to have entered salt water annually (Schiewe 1999). Annually about, 1 million adults have returned to the mouth of the Columbia (ODFW 1998). To obtain the historic number of 10 million adults at 1.0% SAR would require one billion smolts. However, natural smolts, produced in a natural river, entering average ocean conditions, during pre-development time, should have returned more in the range of 2.5 to 5 %, so probably between 200 million and 400 million smolts actually entered the ocean out of 250 million to 500 million which started the migration route (Assuming 80 % survival on the smolt migration in a pristine river.).

If there were 10 million adults, spawning escapement probably was 4 to 6 million, yielding about 2 to 3 million redds. At 4,000 eggs per redd, 8 to 12 billion eggs were deposited. At 10% egg to parr survival, there were 800 million to 1.2 billion parr, which in turn could have produced the 200 to 400 million smolts to the ocean that were required to produce 10 million adults. In order to have produced sustained runs of 10 million adult anadromous salmonids, there must have been much larger numbers of eggs deposited, larger numbers and higher densities of parr in rearing area and of smolts in the migration corridor than under current conditions.

Historically the bulk of the Columbia Run was spring and summer chinook, coho, sockeye and steelhead. Chapman (1986) calculated only 1.25 million fall chinook in his high estimate, so over 80% of the smolts would have been spring migrating, yearling smolts. Therefore, 160 to 320 million spring, yearling smolts would have passed through the estuary and entered the ocean in May and June each year, compared to about 40 million under current conditions. In recent years, when hatchery production in the basin reached nearly 200 million fish, over half of the production was fall chinook that produce sub-yearling, summer-migrating smolts.

The Snake River is generally considered to be the single most important anadromous fish producing tributary of the Columbia River and produced up to half of the spring/summer chinook and summer steelhead in the Columbia basin (NMFS 1995b). The Snake River Basin produced runs in excess of 2 million total adults and probably produced 35 to 75 million smolts or about 15 to 25 percent of the basin total. The upper Columbia River also produced spring chinook, sockeye, and steelhead and the Yakima reportedly was second only to the Snake in chinook, coho and steelhead production. In excess

of half of the total smolt production in the Columbia River basin would have been in the migration corridor at the confluence of the Snake and Columbia - perhaps in the range of 100 to 200 million smolts - most of which would have been spring yearlings.

McNary Dam is the first place smolts are counted below the confluence. At the present time, because of depressed stocks and transportation from Snake River dams, there are only about 2 million spring/summer chinook, 1 million steelhead, half a million sockeye and a few coho arriving at McNary Dam as spring, yearling outmigrants. Another 6-8 million sub-yearling fall chinook smolts arrive somewhat later than the spring migrants. Depending on flow and collection protocols, 60-70 % of the smolts are transported from McNary, leaving only a few million smolts in the river at John Day and The Dalles (Schiewe 1999).

Prior to development of the Columbia basin, there were many more smolts migrating through the migration corridor than there are now, even considering the present magnitude of artificial propagation activities. At some points in the corridor, below the major transportation collection points, there is a fraction of the historical numbers. Between McNary and Bonneville Dams, the number of smolts under current operations is perhaps in the range of 5 to 10 percent of pre-development numbers. Even in the estuary, where the transported smolts have been returned to the river, the density must not be over 25% of pre-development levels. Likewise, the number entering the ocean is a fraction of the number that had to have been entering the ocean in the first half of this century.

Even though the spring floods are controlled and the carrying capacity of the estuary has been reduced, the migration corridor is carrying many fewer fish than it did historically. The lower numbers of migrating fish should act to reduce competition and predation in the migration corridor, estuary and the ocean.

The speed of travel of upriver smolts also serves to reduce interaction and competition in the main stem of the Columbia and the estuary. Bell (1984) gives rates of 13 miles/day (21 km/d) in low flows and 23 miles/day (38 km/d) in moderate flows, as a general average for downstream migrants. Buettner and Nelson (1990) found rates between 18 and 55 km/d (Kilometers per day) for salmon smolts and 38 to 55 km/d for steelhead in the Clearwater and up to 72 km/day for both species in the Snake, Salmon and tributaries. Dawley (1986) found rates of 1 to over 59 km/d in the estuary, depending on size, species and distance traveled, with the faster rates correlated with larger smolts from further upriver. In the free-flowing reaches of the Snake, Clearwater and Salmon, currents in excess of 10 km/hr are common during the spring freshet. Smolts could move in excess of 100 km/d just by holding in the thalweg, but the literature would indicate 40 to 50 km/day is a more likely average in moderate to high flows.

Bell and Dawley comment on differential habitat selection with steelhead choosing the thalweg and

nearer to the surface, subyearling chinook being more likely to follow the shorelines and yearling chinook seeking greater depths. As occurs in rearing areas, habitat partitioning among the species has evolved to reduce interspecific competition.

Habitat partitioning and speed of travel should function to reduce predation, competition and interspecies interactions. The reduced number of smolts in the corridor should also decrease the potential for detrimental interactions. However, the behavior of fish in the hydropower reservoirs and bottlenecks in collection and transportation systems may increase opportunities for interaction. Smolts may be disoriented by slack water and may be concentrated as the fish traveling 50 km/d in free-flowing rivers catch up to the fish traveling 10 km/d in the reservoirs. Smolts have been observed to concentrate in front of dams before they enter the collection system. In the collection and transportation system any habitat partitioning is eliminated, densities are increased and both inter- and intra-specific interactions are forced .

This same effect would occur if recovery was attained and the Snake Basin was producing the 15-20 million natural-origin smolts that the co-managers estimate would be produced.

In terms of upriver fish having impacts on lower river fish, the number of fish entering the river below Bonneville, either by in-river migration or transportation is probably less than 25% of historical numbers. Upriver fish are traveling through the 145 miles (241 km) below Bonneville to salt water in a matter of a few days. Upriver fish do not stop, but continue to move through the estuary at the same rate as they migrate downstream (Dawley et al. 1986). Smolts originating upriver from Bonneville Dam have not been shown to have any affect on smolts originating downriver from Bonneville Dam.

Considerable speculation, but little scientific information, is available concerning the overall effects to listed salmon and steelhead from the combined number of hatchery fish in the Snake/Columbia River migration corridor. In a review of the literature, Steward and Bjornn (1990) indicated that some biologists consider density-dependent mortality during freshwater migration to be negligible; however, they also cited a steelhead study that indicated there may have been a density-dependent effect (Royal 1972, cited in Steward and Bjornn 1990). Hatchery and natural populations have similar ecological requirements and can potentially be competitors where critical resources are in short supply (Lower Granite Migration Study Steering Committee (LGMSC 1993).

Feeding rates may be an indicator that food is a limiting factor in the migration corridor, which could decrease survival to adulthood. However, it may also be an indicator of poor health or stress even when food is not limited (Dawley et al. 1986). Increased flow, turbidity, gas supersaturation, temperature, and migration rate may also be factors affecting feeding efficiency. Bennett and Shrier (1986), cited by the LGMSC (1993) found that most migrating smolts sampled in Lower Granite Reservoir contained food items and numerous stomachs were full; however, some individuals lacked

food. Giorgi (1991) indicated that there is contrasting information on the food habits of yearling chinook salmon at Lower Granite Dam. *Corophium spp.* was the predominant food item in samples collected at Lower Granite Dam in 1987, while guts were generally void of any food items in 1989.

Dawley et al. (1986) studied the migrational characteristics of juvenile salmonids entering the Columbia River estuary. In that study, yearling chinook salmon generally had low stomach fullness values from March through April, but in May and June, the aggregate fullness values of yearling chinook salmon increased and percentages of non-feeding fish for most groups decreased. However, the consumption values for yearling spring chinook salmon (but not in other species sampled) declined from maximum in May, the peak period of salmonid migration. Relatively low mean fullness and empty stomachs were correlated with close proximity of release to recovery site and/or short migration period prior to recovery, early March releases, high turbidity, and disease incidence.

Stomach content weights for sub-yearling and yearling chinook salmon captured at Jones Beach were less than similar sized fish examined at other estuarine and riverine locations; however, some of the comparisons were of fish residing in the estuary versus fish that were actively migrating when sampled at Jones Beach. In a 1980 and 1981 study of the Upper Columbia River estuary, Dawley et al. (1986) found that sub-yearling chinook salmon generally had about half-full stomachs. In a 1992 study involving Bonneville Hatchery fall chinook salmon, Ledgerwood et al. (1993) also found stomachs about half full, even though more hatchery fish are now produced than during the earlier study.

Carrying capacity depends on system productivity, which fluctuates. Variation in productivity is probably linked to climatic cycles as well as to human activities that have altered the habitat in the last 100 years. The FCRPS and other dams constructed for flood control, irrigation storage and hydroelectric generation have substantially altered river flows. Discharge at the mouth of the Columbia River during spring freshets has been reduced between 21 and 28 percent, while discharge during the low-flow period of late summer and fall has been increased by 50 percent. The upstream reservoirs have reduced sediment transport and macrodetritus delivered to the main stem of the Columbia and estuary, but have increased the production of phytoplankton and the transport of microdetritus through the river system. Dredging of navigation channels has increased the amount of deep water habitat in the navigable portion of the Columbia River, while filling of wetlands and levees have reduced the amount of shallow water and wetland habitat. Changes in carrying capacity due to dams and levees may be obscured by water quality or other habitat alteration and natural fluctuations (Weitkamp 1994).

The difficulty of estimating a system's capacity to support salmon is probably further compounded by cycles of oceanic productivity and other ecological and human factors, effects that may be difficult to isolate from each other. Current carrying capacity estimates must be based on present conditions and may be lower than historical levels. However, a reasonable estimate of the current carrying capacity is not available and would be difficult to derive.

The limited information available concerning effects from changes in the historic carrying capacity to listed salmon is insufficient to determine definitive impacts. It is for this reason that NMFS has recommended a limitation of hatchery releases in the Columbia Basin. The effects of hatchery production on listed salmon and steelhead in the ocean would be speculative, since hatchery fish intermingle at the point of ocean entry with natural-origin and hatchery anadromous salmonids from many other regions. Witty et al. (1995) assessing the effects of Columbia River hatchery salmonid production on natural-origin fish stated:

“We have surmised the ocean fish rearing conditions are dynamic. Years of limited food supply affect size of fish, and reduced size makes juveniles more subject to predation (quoted from Parker 1971). Mass enhancement of fish populations through fish culture could cause density-dependant affects during years of low ocean productivity. However, we know of no studies which demonstrate, or even suggest, the magnitude of changes in numbers of smolts emigrating from the Columbia River Basin which might be associated with some level of change in survival rate of juveniles in the ocean. We can only assume that an increase in smolts might decrease ocean survival rate and a decrease might improve ocean survival rate.”

However, the assumptions made by Witty would apply only if the ocean were near carrying capacity. The current production from the Columbia River is lower than the number carried by the migration corridor and ocean in the fairly recent past.

The species of primary concern in the Columbia Basin are chinook salmon, sockeye salmon and steelhead. There is no evidence in the literature to support the speculation that there is some compensatory mortality of chinook salmon and steelhead in the ocean environment. There is evidence of density-dependent compensatory ocean survival in the cases of massive pink and chum salmon hatchery programs in Alaska, Russia and Japan (Pearcy 1992). There are currently two small chum salmon hatchery programs in the Lower Columbia River, the WDFW's Grays River program and the spawning channel on Hamilton Creek below Bonneville Dam. These produce chum salmon at a level that is only a fraction of a percent of the numbers seen in Alaska, Russia and Japan. Pink salmon are extinct in the Columbia. There is evidence for compensatory ocean mortality in sockeye, because this species uses schooling behavior as a defense against predators. Smaller schools are preyed upon at a higher rate than larger schools and therefore, high freshwater mortality can contribute to higher ocean mortality (Pearcy 1992).

The only suggestion of evidence for compensatory ocean mortality for coho is the Oregon Production Index (OPI) coho experience during the brief excursion into industrial hatchery production ("ocean ranching") in the late 1970s-early 1980s period. More coho production appeared to produce fewer adults. However, most of the increased production was from industrial hatcheries utilizing what is now considered to be egregious hatchery practices -- accelerated growth, high rearing densities,

domesticated stocks, etc.. The wild/natural coho and the public hatchery coho occupying the same waters did not show the same effect as the industrial hatchery coho (Nickelson 1986). It appears likely that the OPI experience was a case of poor quality smolts released into a series of poor ocean conditions, rather than strictly a density-dependent effect.

Although the effects of hatchery-produced smolts on naturally produced smolts are difficult to detect and largely hypothetical, the hatchery reform measures recommended in other sections of this opinion will act to control any effects.

- Release smolts that are fully developed and ready to migrate to reduce the time that they might interact with natural-origin smolts.
- Match the size and life history characteristics of artificially produced anadromous salmonids to the naturally occurring fish in the same waters.
- Scale the artificial production numbers to the productive capacity of the receiving waters and adjust artificial propagation numbers when natural production increases.

Table 3. Listed and total salmonid smolts estimated to enter the Columbia River estuary in 1999¹.

Listed smolts entering the Estuary	Total Smolts entering the Estuary²
Spring/summer chinook yearling smolts-listed Upper Columbia-wild 133,934 Upper Columbia-hatchery 380,470 Snake River-wild 754,957 Snake River-hatchery 325,738 Lower Columbia-wild 350,000 ³ Upper Willamette-wild <u>600,000⁴</u> Total spr/sum ck 2,545,369	Spring/summer chinook yearling smolts-total 22.4 to 27.0 million 9 to 11 percent are listed
Fall chinook sub-yearling smolts- listed Snake River-wild 88,704 ⁵	Fall chinook sub-yearling smolts- total 18.2 to 22.4 million 0.4 percent listed
Sockeye salmon smolts -listed Snake River - wild 3,025 Snake River- hatchery <u>15,000</u> Total sockeye 18,025	Sockeye Salmon Smolts-total 500,000 to 1.0 million 1.8 to 3.6 percent listed
Steelhead smolts-listed Snake River basin-wild 715,000 Upper Columbia-wild 61,791 Upper Columbia-hatchery 634,985 Mid-Columbia-wild 208,000 Upper Willamette-wild 210,000 ⁶ Lower Columbia-wild <u>400,000⁷</u> Total steelhead 2,229,776	Steelhead Smolts-total 10.0 to 14.4 million 15.3 to 22.8 percent listed
Chum Salmon smolts-listed Columbia River-wild 1,000,000 ⁸	Chum Salmon Smolts-total 100 percent listed
Coho Salmon Smolts-listed None listed	Coho Salmon Smolts-total 16.0 to 20.0 million None listed
Total listed smolts 5,881,874	Total smolts 68.2 to 85.8 million 6.9 to 8.6 percent listed

¹ Unless otherwise noted, smolt number estimates are from Schiewe, 1999.

² The spread in smolts estimates is based on the scenarios in Schiewe 1999. Generally the upper range represents the full-transportation scenario and the lower range represents the no-transportation scenario.

³ Back-calculated from 3,500 Sandy, Clackamas and other Lower Columbia ESU wild spring

5.1.9 Fisheries Impacts

Fisheries managed for, or directed at, the harvest of hatchery origin fish has been identified as one of the primary factors leading to the decline of many wild salmonid stocks (Flagg et al. 1995; Myers et al. 1998). Depending on the characteristics of a fishery regime, the commercial and recreational pursuit of hatchery fish can lead to the harvest of natural-origin fish in excess of levels compatible with their survival and recovery (NRC 1996). Listed salmon and steelhead may be intercepted in mixed stock fisheries targeting predominately returning hatchery fish or healthy natural stocks (Mundy 1997). Fisheries can be managed for the aggregate return of hatchery and natural-origin fish, which can lead to higher than expected harvest of wild stocks.

Certain management actions can reduce the effects on listed stocks from harvesting hatchery produced fish (Rutter 1997). Hatchery fish can be externally marked so that they can be differentiated from unmarked, natural-origin fish. Fisheries then can be conducted to selectively harvest only hatchery produced fish with natural-origin fish being released. Fisheries can be managed for the cumulative harvest rate from all fisheries to ensure impacts are not higher than expected (Mundy 1997). To ensure harvest rates are not increased because of a large return of hatchery fish, fisheries can be managed based on the abundance and status of natural-origin fish. Hatchery fish can be released from terminal areas so that returning adults can be harvested with little or no interception of natural-origin fish. Fisheries can occur near acclimation sites or in other areas where released hatchery fish have a tendency to concentrate, which reduces the catch of natural-origin fish. Finally, the number of fish released from hatcheries can be reduced or eliminated, if fisheries targeting hatchery fish cannot be managed compatible with the survival and recovery of listed fish.

5.1.10 Nutrient Cycling

The flow of energy and biomass from productive marine environments to relatively unproductive terrestrial environments supports high productivity in the ecotone where the two ecosystems meet (Polis and Hurd 1996). Anadromous salmon are a major vector for transporting marine nutrients across ecosystem boundaries (i.e. from marine to freshwater and terrestrial ecosystems). Because of the long migrations of some stocks of Pacific salmon, the link between marine and terrestrial production may be extended hundreds of miles inland. Nutrients and biomass extracted from the decomposing carcasses, eggs and milt of spawning salmon stimulate growth and restore the nutrients of aquatic ecosystems.

Nutrients originating from salmon carcasses are also important to riparian plant growth. Direct consumption of carcasses and secondary consumption of plants and small animals that are supported by carcasses is an important source of nutrition for terrestrial wildlife (Cederholm, et. al. 1999).

Current escapements of wild and naturally spawning hatchery-produced anadromous salmonids in the Columbia Basin are estimated at about 7 % of the historic biomass (Cederholm et. al. 1999).

Throughout the Pacific Northwest, the delivery of organic nitrogen and phosphorus to the spawning and rearing streams for anadromous salmonids has been estimated at 5 to 7 % of the historic amount (Gresh et. al. 2000). Cederholm et. al. calculate the historical spawning escapement at 45,150 mt (metric ton) of biomass annually added to the aquatic ecosystems of the Columbia compared to 3,400 mt annually with current spawning escapements.

Artificial propagation programs in the basin add substantial amounts of fish biomass to the freshwater ecosystem. The annual hatchery production cap of nearly 200 million smolts, at 25 gr/smolt average weight, adds about 5,000 mt of biomass to the Columbia Basin. Returning adults from artificial propagation programs have totaled 800,000 to 1,000,000 in recent years (ODFW 1998). At the average weight of 6.75 kg used by Cederholm, 5,400 to 6,750 mt of fish biomass is potentially returned to the Columbia River annually due to artificial propagation programs. Of course, most of the hatchery smolt production is expected to leave freshwater and migrate to the marine ecosystem, but undoubtedly some is retained in freshwater and terrestrial ecosystems as post-release mortalities and consumption by predators such as bull trout, ospreys and otters. Much of the adult return from hatchery production may be removed from the ecosystem by selective fisheries or taken at hatchery weirs and traps.

However, the potential to utilize the marine-based nutrients that are imported to freshwater ecosystems in the carcasses of hatchery returns may be of value for stimulating ecosystem recovery. Experiments have shown that carcasses of hatchery produced salmon can be an important source of nutrients for juvenile salmon rearing in streams (Bilby et. al. 1998). Hatchery carcasses may also replace some of the nutrient deficit in riparian plant and terrestrial wildlife communities where wild spawners are lacking. The contribution of artificial propagation programs has the potential to exceed the contribution of naturally produced fish in replenishing the nutrient capital of aquatic ecosystems in the short term, but should not be regarded as a long term solution to replacing the nutrient subsidy provided by wild salmon.

Utilization of carcass outplants and evaluation of results may be incorporated into many of the artificial propagation programs evaluated in this opinion. Managers considering carcass outplants must follow disease control guidelines and should not transfer carcasses between drainages. Managers should also consider other habitat conditions of target streams including the presence of small woody debris that helps retain carcasses as they decompose, the likely natural density of spawner carcasses and the

presence of nutrient enrichment such as agricultural runoff.

5.1.11 Hatchery Program Monitoring and Evaluation

Monitoring and Evaluation programs are necessary to determine the performance of artificial propagation programs. The Artificial Production Review (NPPC 1999) listed four criteria for evaluating both augmentation and mitigation programs:

- 1) Has the hatchery achieved its objectives?
- 2) Has the hatchery incurred costs to natural production?
- 3) Are there genetic impacts associated with the hatchery production?
- 4) Is the benefit greater than the cost?

Historically, hatchery performance was determined solely on the hatcheries ability to release fish (NPPC 1999), this was further expanded to include hatchery contribution to fisheries (e.g. Wallis 1964, Wahle and Vreeland 1978, Vreeland 1989). Recent program wide reviews of artificial propagation programs in the Northwest have identified the failure of regional salmon managers to conduct adequate monitoring and evaluation to determine if the hatchery objectives are being met (ISG 1996, NRC 1996, NFHRP 1994). The lack of adequate monitoring and evaluation has resulted in the loss of information that could have been used to adaptively manage the hatchery programs (NRC 1996).

Under the ESA, monitoring and evaluation programs for artificial production are not only necessary for adaptive management purposes but are required to ensure that artificial propagation activities do not jeopardize listed populations (see Appendix B NMFS' jeopardy standard). Monitoring and Evaluation of artificial propagation activities is necessary to determine if management actions are adequate to reduce or minimize the impacts from the nine general effects discussed previously, and to determine if the hatchery is meeting its performance goals. Monitoring and evaluation activities will occur within the hatchery facilities as well as in the natural production areas. Monitoring and evaluation within the hatchery can include measurements to evaluate hatchery production (i.e. survival, size at age, condition, disease prevention, genetic makeup, total released, percent smolted, etc.).

Monitoring and Evaluation programs to determine impacts to listed populations from artificial propagation activities can have potential adverse effects to listed fish through sampling and marking.

Sampling within the hatchery can include direct mortalities (e.g. genetic analysis, disease pathology, smolt condition) and indirect take (e.g. sorting, marking, transfers). Marking of hatchery fish prior to release is required for all programs, with management requiring 100 percent marking for some releases. Marking is necessary to evaluate a number of objectives including sorting broodstock, determining hatchery stray rates, hatchery contributions to commercial fisheries. There are a number of methods

available to mark hatchery fish (Nielson 1992, Parker et al. 1990). The methods used depend on the type of information required or on the management goal for the hatchery fish. To support selective fisheries, identification when collecting broodstock, tag recovery in fisheries and tag recovery on the spawning grounds external marks are required (PSMFC 1992). Internal tags and marking methods (PSMFC 1992, Volk 1990, Bilton 1986) can be used to evaluate fisheries contribution, broodstock origin (post spawning) and contribution to natural spawning via carcass recovery. Each marking method has unique risks associated with the tag and the method of application (Parker et al. 1990, Jacobs 1990) and these risks must be considered when developing monitoring and evaluation plans.

In many artificial propagation programs the goal is to increase natural production (supplementation, augmentation, restoration) by using hatchery fish to increase the number of natural spawners. Monitoring and evaluation for this goal requires the sampling of naturally produced adults and juveniles in natural production areas. In the Columbia River Basin, many of these naturally produced populations are listed under ESA.

Monitoring and evaluating naturally produced fish is required to determine if the artificial production program is having any adverse effects on the natural population. Genetic and life history data must be collected from the natural population to determine if the hatchery population has diverged from the natural population and if the natural population has been altered by the incorporation of hatchery fish into the spawning population. To collect these data, the natural population needs to be sampled. Sampling methods can include the use of weirs, electro-fishing, rotary screw traps, seines, hand nets, spawning ground surveys, snorkeling, radio tagging and carcass recovery. Each sampling method can be used to collect a variety of information. Sample methods, like tagging methods, can potentially adversely effect listed fish both those targeted for data collection and those taken incidentally to the data collection.

NMFS has developed some general guidelines for collecting listed adult and juvenile salmonids (NMFS 1998, NMFS 2000) which have been incorporated as terms and conditions into section 10 and section 7 permits for research and enhancement activities (e.g. NMFS 1999). Though necessary to monitor and evaluate impacts to listed populations from artificial propagation programs, monitoring and evaluations programs should be designed and coordinated with other plans to maximize the data collection while minimizing take of listed fish.

5.2 Specific Effects on Listed Populations

NMFS has not determined the population structure of the listed ESUs in the Upper Willamette Basin. This will be done as a part of recovery planning by the “Technical Recovery Teams” in the future. The “populations” identified and used below correspond to 4th field HUC designations and are used only for the purposes of evaluating the proposed actions in this consultation.

Below are the specific effects on listed ESUs directly and indirectly affected by the proposed actions. Given the analysis in section 5.1, the primary effects of the proposed actions are evaluated below with respect to the specific populations. Of particular importance to the evaluation of the specific effects on listed populations below is that most of the hatchery programs are to mitigate for the loss and degradation of habitat in the Willamette River Basin.

The above general analysis of effects formed the basis for evaluating the specific effects of the proposed actions to listed juvenile and adult fish in each of the subbasins identified below. Some of the effects discussed above are not applicable to every subbasin and/or listed species.

5.2.1 Clackamas Subbasin

The potential effects from the operation of Clackamas Hatchery to listed spring chinook and winter steelhead in the subbasin is low. The Clackamas Hatchery uses water from Clackamas River and Dog Creek. The water is passed through the hatchery facility and returned to the river, with no net loss of water. No measurable impacts to listed fish are likely to occur.

5.2.1.1 Spring chinook

5.2.1.1.1 Adults

The primary direct effects of the proposed actions on adult spring chinook in the Clackamas Subbasin is from the straying of hatchery spring chinook onto natural spawning grounds and the collection of natural-origin spring chinook for hatchery broodstock. In the past, hatchery fish could not be differentiated from natural-origin spring chinook with absolute certainty. However, since 1996 all hatchery chinook smolts have been externally marked. In 2002 all returning Clackamas hatchery chinook will be externally marked. This will allow hatchery chinook to be differentiated from naturally-produced fish with certainty.

The best available information on the proportion of hatchery fish potentially straying onto natural spawning areas in the Clackamas Subbasin is from fish counts at North Fork Dam (Figure 3). From 1996-99, counts of spring chinook at the dam have ranged from 888 to 1,270, with hatchery fish representing an estimated 50% of the total counts (ODFW 2000 staff report). The general effects of hatchery fish interbreeding natural-origin fish was discussed above in section 5.1.2. However, Neeley (1996) conducted an analysis of the effects of hatchery fish straying on wild gene frequencies in naturally spawning Willamette River stocks. In particular, the effects of Clackamas Hatchery spring chinook straying on the wild chinook above North Fork Dam were assessed. Assuming a 40% hatchery fish stray rate, results of this study suggest that wild gene frequencies have been significantly affected by the straying of hatchery fish above the dam (Figure 31). Neeley also analyzed the change in

wild gene frequencies if the proportion of hatchery fish was reduced to 10% in the year 2000. As shown in Figure Figure 31, the wild gene frequency generally begins to increase, but never regains the

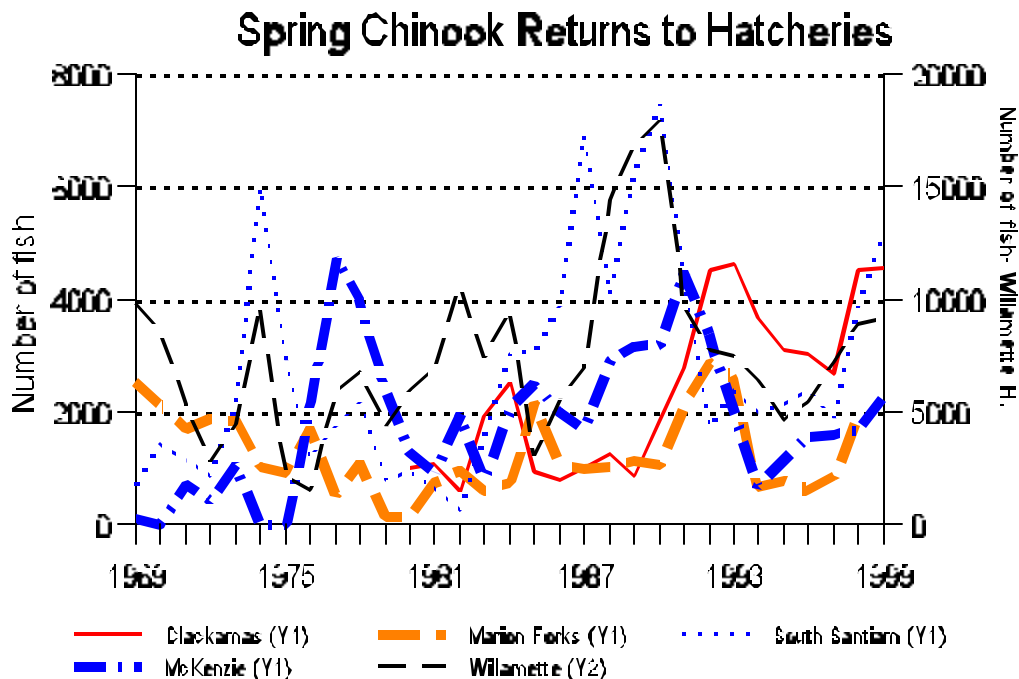


Figure 30. Number of spring chinook salmon returning to hatcheries within the Willamette River Basin 1969-1999. Data from ODFW and WDFW (1999).

original gene frequency in the wild population 100 years into the future. Given the results of Neeley's (1996) model, the evaluation of genetic introgression in section 5.1, and Grant (1997), the straying of hatchery spring chinook salmon above North Fork Dam has a high likelihood of reducing the survival and recovery potential of natural-origin chinook in the Upper Clackamas River.

However, the abundance of spring chinook increased substantially above North Fork Dam in the early 1980's, corresponding to the beginning of adult hatchery spring chinook returns from smolt releases at Clackamas Hatchery (Figure 16). It is unknown if the additional hatchery fish spawning in the Upper Clackamas River have actually decreased or increased productivity of the indigenous, wild spring chinook. Before Clackamas hatchery fish returns, counts of spring chinook at North Fork Dam were typically 300 to 600 fish annually. Since the hatchery fish are unmarked, the true status of natural-origin spring chinook is masked by the presence of hatchery fish.

The release of hatchery smolts (185,000 fish) from McKenzie Hatchery stock is proposed for release into the Lower Clackamas River. This action can potentially affect the natural-origin chinook

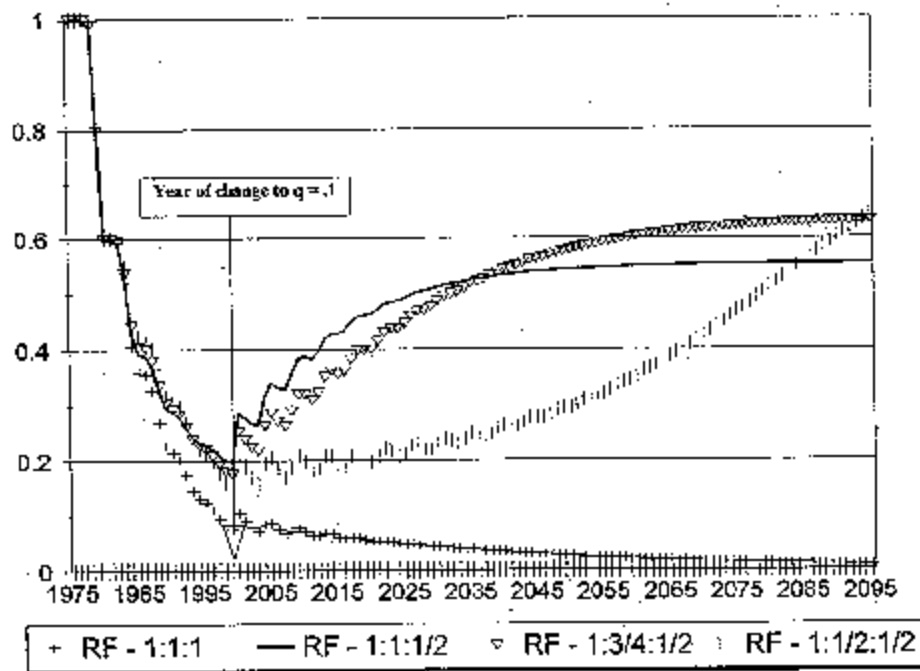


Figure 31. Example of the potential ramifications of hatchery chinook spawning with natural-origin chinook. Model simulations of the change in frequency of a wild-type gene in the naturally spawning population of Clackamas spring chinook above N.F. Dam. From 1976 to 1999, the model assumed 40% of the natural spawners were hatchery origin. Beginning in 2000 the proportion of hatchery fish spawners was reduced to 10%. Graph reproduced from Neeley (1996).

population in the Clackamas Subbasin when these hatchery fish return as adults. Willis et al. (1995) summarized an ODFW study evaluating the homing of South Santiam hatchery fish (brood years 1975-78). Results of this study suggest that hatchery spring chinook trucked and released into the Lower Willamette River showed decreased homing fidelity compared to hatchery smolts released directly from the South Santiam Hatchery. Of the smolts released from the South Santiam Hatchery, 97% of the adult recoveries occurred at the South Santiam Hatchery. Of the fish trucked from the hatchery and released into the Lower Willamette River, only 23% of the adult recoveries were at the South Santiam Hatchery. Other recoveries occurred at Clackamas Hatchery (33%), McKenzie Hatchery (22%), and Minto Pond (10%) on the North Santiam River. Lindsay et al. (1998 and 1999) also found a similar pattern of increased straying of McKenzie hatchery stock that were acclimated and released into the Lower Willamette River. Given these results, it appears likely that McKenzie River hatchery fish trucked and released into the Lower Clackamas River could stray into the Clackamas Subbasin when they return as adults at a significant rate, potentially resulting in the genetic introgression of McKenzie hatchery stock into the Clackamas wild population.

The Clackamas Hatchery spring chinook program can also impact natural-origin chinook from the collection of broodstock. In addition to natural-origin fish being used for broodstock purposes, chinook returning to the hatchery in excess of the 750 broodstock target may be sold or disposed. Fish in excess of broodstock needs has been high since 1990 (Figure 30). Naturally produced chinook could be included in the excess fish and not used for the hatchery program. The actual number of natural-origin fish collected at Clackamas Hatchery is unquantified because natural-origin fish could not be differentiated from hatchery fish in the past. However, Nandor (2000) suggested that the number of natural-origin fish incorporated into the broodstock annually was very low. Given that broodstock for the program are proposed to be taken from fish returning to the hatchery trap in Dog Creek, a small tributary to the Clackamas River (which does not likely support natural production of spring chinook), the likelihood of natural-origin chinook being taken into the broodstock (750 fish goal) at a significant degree is low. In addition, since most of the natural-origin spring chinook in the Clackamas Subbasin spawn above North Fork Dam (Lindsay 1997, 1998, 1999) and the attraction for natural-origin fish to enter Dog Creek (i.e. low water flow) is minor, the risk of natural-origin fish being captured in the hatchery trap is low. This could also affect the fidelity of hatchery fish homing back to the hatchery trap. However, the percentage of the hatchery fish return to the Clackamas River that actually enters the hatchery trap is not quantified.

An indirect effect on natural-origin adult spring chinook from the release of hatchery spring chinook are the impacts associated with fisheries occurring on the hatchery chinook when they return as adults. In the past, Willamette River hatchery spring chinook have supported popular fisheries with harvest rates in the Lower Willamette River alone being relatively high (Figure 24). The harvest rate of spring chinook in the Clackamas River is estimated to be an additional 26% (ODFW 2000 staff report). It is unclear if the presence of hatchery fish in the Clackamas has increased the harvest of natural-origin fish or has provided a buffer on harvesting natural-origin fish because most of the catch is hatchery fish. It does appear, however, that the level of hatchery spring chinook production since the late 1970's supports adult returns that are consistently higher than fishery and broodstock demands (Figure 30).

It is uncertain if a surplus of hatchery chinook will continue to occur at Clackamas Hatchery under the selective fishing regime being implemented in 2001-02 because only hatchery fish will be retained and all natural-origin fish will be released. Previously, natural-origin and hatchery fish were retained in fisheries, which may have increased the escapement of hatchery fish; especially if natural-origin fish made up a substantial portion of the total catch.

The last few years, ODFW has been evaluating potential impacts associated with selective fishery on hatchery spring chinook in the Willamette River Basin. Preliminary information suggests the mortality of natural-origin spring chinook under a selective fishery regime in the Lower Willamette would be approximately 3% of the return to the river (Lindsay et al. 1998, 1999). These studies are probably the most accurate estimates of the catch and release mortality of spring chinook because the differential

mortality associated with using certain fishing techniques and tackle characteristic of the Willamette fishery were taken into account in the estimates. Given that all hatchery spring chinook have been externally marked since 1996 and the information on catch and release mortality, it appears unlikely that the continued release of hatchery fish poses a substantial threat to the wild population in the Clackamas River from being overharvested in fisheries. This assumes that selective fisheries will be implemented as planned in 2002.

5.2.1.1.2 Juveniles

The release of juvenile hatchery chinook can also directly and indirectly impact natural-origin chinook that may be rearing in the stream. The effects of the release of juvenile hatchery fish on listed species was fully evaluated in section 5.1. As discussed in section 3 above and depicted in Figure 3, most of the natural production of spring chinook in the Clackamas Subbasin occurs upstream of North Fork Dam. Since the release of smolts occurs from Clackamas Hatchery, which is downstream from North Fork Dam, the potential for interaction between hatchery fish and natural-origin fish rearing in the stream is greatly reduced. However, during winter and spring, hatchery smolts could co-occur in the stream with natural-origin chinook smolts which are emigrating to the ocean. Since the size of hatchery and natural-origin fish emigrating during this period is relatively similar, predation of hatchery fish on natural-origin smolts is unlikely (Pearson and Fritts 1999). Competition or density-dependent effects could occur. However, since the fish are actively moving downstream, it is uncertain if biological resources would be in limited supply. No information was available on the degree of residualism and disease transmission from hatchery to natural-origin chinook in the Willamette Basin.

5.2.1.2 Winter steelhead

Winter steelhead in the Clackamas Subbasin have been determined to be part of the Lower Columbia River ESU. The impacts of the hatchery spring chinook to listed winter steelhead in the Clackamas is assessed below. The impacts from the steelhead hatchery programs in the Clackamas are evaluated in NMFS' Biological Opinion for the Lower Columbia River steelhead ESU.

5.2.1.2.1 Adults

Impacts to listed adult winter steelhead in the Clackamas Subbasin from the hatchery spring chinook program are likely to be negligible. Native winter steelhead return to the Clackamas primarily from February through May. Adult hatchery spring chinook return to the Clackamas River primarily from April through September. The only likely adverse effect of hatchery chinook on listed steelhead may be in the form of behavior changes in adult steelhead when adult hatchery chinook may also be present in the Clackamas River. However, this effect is unquantified and does not likely result in decreased survival or reproduction of listed adult steelhead.

5.2.1.2.2 Juveniles

The effects of hatchery chinook on listed juvenile steelhead are likely to be minor. Adult hatchery chinook are not likely to adversely affect juvenile steelhead that may be rearing in stream. Juvenile hatchery chinook may co-occur with juvenile steelhead in the lower 23 miles of the Clackamas River (hatchery to the mouth). However, the most likely effect would be predation of hatchery chinook on age-0 steelhead. Clackamas River steelhead are a relatively late returning winter run, spawning primarily March through June. Age-0 steelhead typically incubate in the gravel for more than 45 days and are not likely to have emerged during the period when hatchery chinook are released (February through May). Age-1+ steelhead that may be present in the Lower Clackamas are likely to be greater than 80 mm (Shibahara et al. 1998), thus resulting in a low likelihood of being eaten by hatchery spring chinook which are of similar size (Pearsons and Fritts 1999).

5.2.2 Molalla Subbasin

Hatchery releases of summer and winter steelhead were eliminated in 1999 (see section 2.2). Only hatchery spring chinook are proposed for release into the Molalla Subbasin. No broodstock are collected from the subbasin. The primary effects on listed species in the subbasin would be associated with the release of hatchery chinook and the return of hatchery spring chinook adults. These specific effects are evaluated below.

5.2.2.1 Spring chinook

5.2.2.1.1 Adults

The best available information suggests the wild population of spring chinook in the Molalla Subbasin is extinct (Kostow 1995; Nicholas et al. 1995; Myers et al. 1998). If naturally spawned fish occur in the Molalla Subbasin, they are likely offspring from hatchery spring chinook, which have been released in an effort to reestablish natural production (Nicholas et al. 1995). If it is assumed that the indigenous chinook population is extinct, then adult hatchery chinook spawning in the river would likely increase natural production in the subbasin, which would be beneficial given the current status of chinook in the Molalla. The USGS (Wentz et al. 1998) showed water quality, habitat quality, and the native fish community in the Molalla Subbasin to be severely altered. Given the current degraded condition of the subbasin, allowing hatchery chinook to spawn naturally appears to be an appropriate strategy to increase production (in terms of benefits from additional spawning and from the indirect and direct effect carcasses, see section 5.1) and will not likely impact the natural-origin fish that may be present.

An indirect effect on natural-origin adult spring chinook from the release of hatchery spring chinook are the impacts associated with fisheries occurring on the hatchery chinook when they return as adults. In

the past, Willamette River hatchery spring chinook have supported popular fisheries with harvest rates in the Lower Willamette River alone being relatively high (Figure with harvest rates). The harvest rate of spring chinook in the Molalla River is unknown but is likely to be similar to harvest rates observed in other tributaries. These harvest rates have ranged from 20% to 30% (ODFW 2000 staff report).

The last few years, ODFW has been evaluating potential impacts associated with selective fishery on hatchery spring chinook in the Willamette River Basin. Preliminary information suggests the mortality of natural-origin spring chinook under a selective fishery regime in the Lower Willamette would be approximately 3% of the return to the river (Lindsay et al. 1998, 1999). These studies are probably the most accurate estimates of the catch and release mortality of spring chinook because the differential mortality associated with using certain fishing techniques and tackle characteristic of the Willamette fishery were taken into account in the estimates. Given that all hatchery spring chinook have been externally marked since 1996 and the information on catch and release mortality, it appears unlikely that the continued release of hatchery fish poses a substantial threat to recovery efforts to establish a naturally spawning chinook population in the Molalla Subbasin. This assumes that selective fisheries will be implemented as planned in 2002.

5.2.2.1.2 Juveniles

As discussed above, the status of the indigenous chinook population is likely to be extinct. If offspring from hatchery fish that spawned in the subbasin are present, the release of hatchery smolts may affect these natural fish. Impacts are likely to be from the hatchery smolts consuming the smaller fry. However, the duration of this potential impact will be low since the smolts are actively emigrating to the ocean.

5.2.2.2 Winter steelhead

Releases of Big Creek hatchery winter steelhead (non-ESU stock) were eliminated in 1999. The returns of early run winter steelhead should decrease substantially in the next few years.

5.2.2.2.1 Adults

Impacts to winter steelhead from the hatchery spring chinook program are likely to be very low. Hatchery chinook return from May through July to the Molalla. Winter steelhead return earlier and are likely to have spawned by the time spring chinook may be present. Spring chinook spawn in September and October (Nicholas et al. 1995), so there is no chance of hatchery chinook superimposing on winter steelhead redds before the juvenile steelhead emerge from the gravel (May through July).

5.2.2.2.2 Juveniles

The release of hatchery spring chinook smolts may affect winter steelhead juveniles. Since age-0 steelhead are not likely to have emerged from the gravel during the period when hatchery chinook are released (February and March), impacts should be low or non-existent. Hatchery smolts may compete with older age steelhead (age-1+) rearing in the stream. Age-1+ steelhead are large enough to minimize the risk of being consumed by hatchery chinook smolts (Pearsons and Fritts 1999). These potential effects will be of limited duration because hatchery smolts are actively emigrating to the ocean when released.

5.2.3 North Santiam Subbasin

The specific effects on listed spring chinook in the North Santiam Subbasin are likely to occur from hatchery chinook spawning with natural-origin fish and from collecting natural-origin fish for broodstock in the Marion Forks hatchery program. Potential adverse effects to juvenile spring chinook are likely to result from the release of juvenile hatchery spring chinook and summer steelhead in the North Santiam Subbasin. Adult winter steelhead are not likely to be present during the periods when spring chinook and summer steelhead are collected for broodstock. Below is the analysis of effects on listed adult and juvenile spring chinook and listed juvenile and adult winter steelhead.

5.2.3.1 Spring chinook

5.2.3.1.1 Adults

Impacts from the proposed actions on adult spring chinook in the North Santiam Subbasin are primarily from hatchery fish interbreeding with natural fish in the wild and from collecting natural-origin chinook for hatchery broodstock.

Since hatchery fish could not be differentiated from natural-origin fish on the spawning grounds, it has been difficult to determine the percentage of spawners that were of hatchery origin. However, some information suggests that hatchery fish comprised a substantial number of natural spawners. Due to the Minto trap only being open long enough to collect sufficient broodstock and because the uppermost point of return is at the trap, Cramer et al. (1996) suggested that 50% of the hatchery fish return could have spawned naturally. Minto trap is located approximately 3 miles below Big Cliff Dam, which blocked all upstream passage in 1953. Since hatchery chinook are released at Minto trap, it would be expected that many hatchery fish would spawn in the mainstem because they cannot migrate upstream and because they do not have any other specific place to home back to. As analyzed in section 5.1 hatchery fish can interbreed with natural-origin fish, resulting in reduced fitness of the wild population. It is assumed that wild gene frequencies could have changed from hatchery interbreeding in the North

Santiam similar to that modeled by Neeley (1996) for the Clackamas River (Figure 31). Some natural spawning of chinook is known to occur in the Little North Santiam River, a tributary to the North Santiam River at rivermile 39. However, the proportion of hatchery fish spawning in this tributary is unknown. A lower proportion of hatchery fish would be expected to occur in this tributary because hatchery smolts are released from the Minto trap.

Impacts to the wild population from the collection of natural-origin fish for broodstock at Minto trap is unknown. Since the Minto trap is the uppermost extent of the current distribution of spring chinook, impacts are localized and interception of natural-origin fish that may be returning elsewhere within the subbasin is minimized. Incorporating a significant percentage of natural-origin fish into the broodstock, from the volitional returns to the Minto trap, would likely reduce impacts associated with hatchery fish spawning in the wild downstream. In this case, using natural-origin fish in the broodstock may be the best strategy and would likely reduce the deleterious effects associated with hatchery and natural-origin spring chinook interbreeding.

Based on the results observed from outplanting adult spring chinook above Cougar Dam in the McKenzie Subbasin (see section 5.2.5 and Corps 1999). Releasing hatchery chinook that return to the Minto trap could increase natural production in the streams above the dams that were once accessible to spring chinook. The benefits of this action would be producing offspring which could utilize the currently vacant habitat and supplying juvenile salmonids and the stream ecosystem with additional nutrients from the spawned out chinook carcasses.

An indirect effect on natural-origin adult spring chinook from the release of hatchery spring chinook are the impacts associated with fisheries occurring on the hatchery chinook when they return as adults. In the past, Willamette River hatchery spring chinook have supported popular fisheries with harvest rates in the Lower Willamette River alone being relatively high (Figure 24). The harvest rate of spring chinook in the North Santiam River is estimated to be an additional 24% (ODFW 2000 staff report). It is unclear if the presence of hatchery fish in the North Santiam has increased the harvest of natural-origin fish or has provided a buffer on the harvesting natural-origin fish because most of the catch is hatchery fish.

The last few years, ODFW has been evaluating potential impacts associated with selective fishery on hatchery spring chinook in the Willamette River Basin. Preliminary information suggests the mortality of natural-origin spring chinook under a selective fishery regime in the Lower Willamette would be approximately 3% of the return to the river (Lindsay et al. 1998, 1999). These studies are probably the most accurate estimates of the catch and release mortality of spring chinook because the differential mortality associated with using certain fishing techniques and tackle characteristic of the Willamette fishery were taken into account in the estimates. Given that all hatchery spring chinook have been externally marked since 1996 and the information on catch and release mortality, it appears unlikely that

the continued release of hatchery fish poses a substantial threat to the natural-origin population in the North Santiam River from being overharvested in fisheries. This assumes that selective fisheries will be implemented as planned in 2002.

5.2.3.1.2 Juveniles

The release of hatchery chinook is likely to impact to natural-origin juvenile chinook in the North Santiam Subbasin. Hatchery chinook are released at Minto trap (the uppermost extent of anadromous fish distribution). Hatchery fish will be emigrating through areas in which natural-origin juvenile fish are likely to be present because it is the only area currently available for spawning, besides the Little North Santiam River. Hatchery smolts are proposed for release in February through April. It is likely that age-0 fry (< 50 mm) would have emerged from the gravel and be present in low velocity areas of the North Santiam River. Hatchery smolts would be large enough to consume natural-origin chinook fry. The hatchery smolts could also compete with natural-origin age-1+ chinook that may be present. Since the chinook are released as smolts, it would be expected that the fish will emigrate quickly through the North Santiam River. Since the distance from the release point to the mouth of the North Santiam River is approximately 55 miles, the potential impacts should be of short duration.

The release of hatchery summer steelhead smolts would be expected to result in similar impacts to natural-origin juvenile chinook as mentioned above for hatchery chinook smolts.

5.2.3.2 Winter steelhead

5.2.3.2.1 Adults

The impacts on adult winter steelhead from the hatchery spring chinook program are low. Listed winter steelhead in the North Santiam return from February through May. Hatchery spring chinook pass Willamette Falls primarily April through August. Because of the temporal separation of run timing between winter steelhead and spring chinook, effects are likely to be low. Hatchery chinook smolts emigrate during the period when winter steelhead are present in the North Santiam Subbasin. However, no adverse effects are likely to occur because winter steelhead are significantly larger.

The summer steelhead hatchery program has the potential to substantially impact winter steelhead in the North Santiam Subbasin. Chilcote (1998) conducted an analysis of the effects of non-native summer steelhead on native Clackamas River winter steelhead. He showed a decrease in the productivity of Clackamas winter steelhead from the introduction of naturally spawning non-native summer steelhead. Chilcote's analysis has implications to the North Santiam, where non-native summer steelhead and indigenous winter steelhead co-occur. The purpose of the summer steelhead hatchery program is to provide harvest opportunities and removal all of the returning summer steelhead. However, it is not

known to what extent summer steelhead spawn naturally in the North Santiam Subbasin. If summer steelhead spawn naturally, it is assumed the North Santiam winter steelhead population would exhibit a decrease in stock productivity similar to that in the Clackamas River.

Recreational fishing for hatchery summer steelhead is not expected to impact winter steelhead because of the temporal separation in the runs. Summer steelhead return to the North Santiam primarily from May through September.

5.2.3.2.2 Juveniles

Since winter steelhead in the Upper Willamette ESU spawn from February through June, the age-0 fish will likely still be in the gravel incubating when the hatchery summer steelhead and spring chinook smolts are released from February through May. Older aged (> 1 year old) steelhead will likely be affected by juvenile hatchery fish in the North Santiam. However, because the natural-origin and hatchery are of relatively similar size (>80 mm), risks of predation are low (Pearsons and Fritts 1999). Competition may occur, but since the hatchery smolts are actively emigrating to the ocean, this effect should be of limited duration.

5.2.4 South Santiam Subbasin

Impacts from the proposed actions are likely to affect spring chinook and winter steelhead in the South Santiam Subbasin. The effects of the actions are primarily related to the release of hatchery smolts, the collection of spring chinook broodstock, and the spawning of hatchery chinook in the wild. Adult winter steelhead are not likely to be present during the periods when spring chinook and summer steelhead are collected for broodstock. Below is the analysis of the likely effects on listed adult and juvenile spring chinook and listed juvenile and adult winter steelhead.

5.2.4.1 Spring chinook

5.2.4.1.1 Adults

The limited information on spring chinook below Foster Dam in the South Santiam River suggests that some natural spawning occurs (see section 3 above). However, it is unknown what proportion of the natural spawners are hatchery fish. Since Foster Dam blocked access to nearly all historical spawning areas in 1966, it is unknown if a remnant, indigenous population still exists below Foster Dam. Since hatchery spring chinook are released and collected at Foster Dam (the uppermost extent of natural passage), it is likely that hatchery fish have spawned below the dam and have significantly affected (like shown in Figure 31) the remaining wild population (if it still exists).

Based on the results observed from outplanting adult spring chinook above Cougar Dam in the McKenzie Subbasin (see section 5.2.5 and Corps 1999). Releasing hatchery chinook that return to the Foster Dam trap could increase natural production in the streams above the dams that were once accessible to spring chinook. The benefits of this action would be producing offspring which could utilize the currently vacant habitat and supplying juvenile salmonids and the stream ecosystem with additional nutrients from the spawned out chinook carcasses.

An indirect effect on natural-origin adult spring chinook from the release of hatchery spring chinook are the impacts associated with fisheries occurring on the hatchery chinook when they return as adults. In the past, Willamette River hatchery spring chinook have supported popular fisheries with harvest rates in the Lower Willamette River alone being relatively high (Figure 24). The harvest rate of spring chinook in the South Santiam River is likely to be at least an additional 20%.

The last few years, ODFW has been evaluating potential impacts associated with selective fishery on hatchery spring chinook in the Willamette River Basin. Preliminary information suggests the mortality of natural-origin spring chinook under a selective fishery regime in the Lower Willamette would be approximately 3% of the return to the river (Lindsay et al. 1998, 1999). These studies are probably the most accurate estimates of the catch and release mortality of spring chinook because the differential mortality associated with using certain fishing techniques and tackle characteristic of the Willamette fishery were taken into account in the estimates. Given that all hatchery spring chinook have been externally marked since 1996 and the information on catch and release mortality, it appears unlikely that the continued release of hatchery fish poses a substantial threat to establishing a naturally spawning population in the South Santiam River from being overharvested in fisheries. This assumes that selective fisheries will be implemented as planned in 2002.

5.2.4.1.2 Juveniles

In attempts to increase natural production in the subbasin, adult hatchery chinook have been outplanted above Foster Dam and in several tributaries to the South Santiam River below Foster Dam (Lindsay et al. 1998). It is likely that some natural production has occurred and juveniles may be present when hatchery chinook and summer steelhead smolts are released at South Santiam Hatchery. Naturally produced age-0 chinook fry are likely to have emerged from the gravel and present in slow velocity areas of the stream. Hatchery smolts could potentially consume natural-origin fry because of their size (Pearsons and Fritts 1999). However, the interaction period is of limited duration because the hatchery smolts are actively emigrating. Naturally produced age-1+ chinook will emigrating during the time periods when hatchery smolts are released. Predation of natural-origin smolts is not likely and potential competitive effects are not known.

5.2.4.2 Winter steelhead

5.2.4.2.1 Adults

The impacts on adult winter steelhead from the hatchery spring chinook program are low. Listed winter steelhead in the South Santiam return from February through May. Hatchery spring chinook pass Willamette Falls primarily April through August. Because of the temporal separation of run timing between winter steelhead and spring chinook, effects are likely to be low. However, in years when the return of spring chinook is high, late arriving winter steelhead could be affected in the fish ladder at Foster Dam by the overcrowding of chinook (V. Shawe, ODFW South Santiam Hatchery, personal communication 4/25/00). Hatchery chinook smolts emigrate during the period when winter steelhead are present in the South Santiam Subbasin. However, no adverse effects are likely to occur because winter steelhead are significantly larger.

The summer steelhead hatchery program has the potential to substantially impact winter steelhead in the South Santiam Subbasin. Chilcote (1998) conducted an analysis of the effects of non-native summer steelhead on native Clackamas River winter steelhead. He showed a decrease in the productivity of Clackamas winter steelhead from the introduction of naturally spawning non-native summer steelhead. Chilcote's analysis has implications to the South Santiam, where non-native summer steelhead and native winter steelhead co-occur. The purpose of the summer steelhead hatchery program is to provide harvest opportunities and not allow summer steelhead to spawn in the wild. However, it is not known to what extent summer steelhead spawn naturally in the South Santiam Subbasin. If summer steelhead spawn naturally, it is assumed the South Santiam winter steelhead population would exhibit a decrease in stock productivity similar to that in the Clackamas River. However, no summer steelhead are proposed to be passed above Foster Dam. This will eliminate all potential effects to the winter steelhead population above Foster Dam (Figure 19, Figure 22).

Recreational fishing for hatchery summer steelhead is not expected to impact winter steelhead because of the temporal separation in the runs. Summer steelhead return to the South Santiam primarily from May through September. Many of the summer steelhead captured at Foster Dam are released downstream so they have the potential of being caught in the fishery again. This promotes the removal of summer steelhead.

5.2.4.2.2 Juveniles

Since winter steelhead in the Upper Willamette ESU spawn from February through June, the age-0 fish will likely still be in the gravel incubating when the hatchery summer steelhead and spring chinook smolts are released from February through May. Age 1+ steelhead will likely be affected by juvenile hatchery fish in the South Santiam. However, because the natural-origin and hatchery are of relatively similar size (>80 mm), risks of predation are low (Pearsons and Fritts 1999). Competition may occur, but

since the hatchery smolts are actively emigrating to the ocean, this effect should be of limited duration. The juvenile winter steelhead population above Foster Dam will not be affected by hatchery summer steelhead and spring chinook. However, catchable, resident rainbow trout are stocked into Foster Reservoir for angling opportunities. Listed juvenile winter steelhead rearing or emigrating through the reservoir may be impacted by the larger rainbow trout through displacement, competition, or predation (see section 5.1 above). Juvenile steelhead may be incidentally caught and retained in the fishery if they are greater than eight inches in length under current fishing regulations. Juvenile fish may also be caught and released with an associated mortality (Mongillo 1984).

5.2.5 McKenzie Subbasin

5.2.5.1 Spring chinook

The specific effects on listed spring chinook in the McKenzie Subbasin are likely to occur from hatchery chinook spawning with natural-origin fish and from collecting natural-origin fish for broodstock in the McKenzie hatchery program. Potential adverse effects to juvenile spring chinook are likely to result from the release of hatchery spring chinook, hatchery rainbow trout and hatchery summer steelhead in the McKenzie Subbasin. Below is the analysis of effects on listed adult and juvenile spring chinook.

5.2.5.1.1 Adults

In previous years, the spawning of hatchery chinook in some potential natural production areas has been high. Willis et al. (1995) stated that 63%, 59%, and 47% of the natural spawners below Leaburg Dam in 1990, 1994, and 1995, respectively were hatchery fish. From 1994 to 1999, the percentage of hatchery spring chinook above Leaburg Dam has ranged from 15-45% (ODFW 2000 staff report). Based on the recovery of CWTs in 1998 (BY 1994), ODFW (1998) found returns to Leaburg Dam from hatchery spring chinook released in Youngs Bay, Lower Willamette River, S. Santiam, and the Middle Fork Willamette. Most of these fish were McKenzie hatchery stock, but South Santiam and Willamette hatchery stocks were also present. In the same report, CWTs collected from carcasses in the McKenzie River below Leaburg Dam showed fish from Clackamas and South Santiam hatchery stock. Most of the fish recovered in the McKenzie River that were non-McKenzie hatchery stock had been transferred to McKenzie Hatchery at some point for rearing. Similar recoveries of non-McKenzie hatchery stock in the McKenzie Subbasin occurred in 1997 (ODFW 1997)

The action agencies propose to allow up to 30% of the spring chinook passing Leaburg Dam to be hatchery fish (ODFW 1998b). Cramer et al. (1996) thought the high proportion of natural spawners below Leaburg Dam that were hatchery fish could be attributed to the small stream where the hatchery is located, thus providing relatively low attraction to returning hatchery adults, and unimpeded access

spawning habitat in the McKenzie River from the mouth to Leaburg Dam.

As assessed in sections 5.1.2 and 5.2.1, the interbreeding between hatchery and natural-origin chinook salmon can result in genetic changes to the indigenous McKenzie River natural-origin population (Grant 1997). It is unclear if the relationship between McKenzie hatchery fish and natural-origin fish is similar to the relationship modeled by Neeley (1996) for the Clackamas River (Figure 24). The McKenzie hatchery stock has been derived from indigenous McKenzie Subbasin spring chinook and has likely incorporated natural-origin fish into the broodstock on a regular basis, which would change the theoretical relationship. However, a conservative approach would be to assume that a similar relationship would occur in the McKenzie Subbasin. In this case, the chinook hatchery program could have a substantial impact on the natural-origin spring chinook population in the McKenzie Subbasin from hatchery fish spawning in the wild (see section 5.1 above).

The McKenzie Hatchery spring chinook program can also impact natural-origin chinook from the collection of broodstock. Since all of the hatchery spring chinook returns have not been externally marked, the percentage of the return to the McKenzie hatchery that were natural-origin fish is not certain. From 1997 to 1999, Nandor (2000) estimated the proportion of the return to the hatchery that were natural-origin fish ranged from 13.5% to 24.8%. In 1997 and 1998, the percentage of the total natural-origin run to the McKenzie Subbasin that entered the hatchery was 15% and 17%, respectively. The risk of a significant proportion of the total wild run in the McKenzie is low because of the low attraction for adults to return to the small stream where the hatchery is located.

In the past, natural-origin chinook could have been included in the excess fish that were disposed of and not used for the hatchery program or allowed to spawn naturally (Figure 30). This potential impact could be reduced in 2000 and beyond if only hatchery fish are disposed of and unmarked, natural-origin fish are released to spawn naturally or used in the broodstock.

In recent years, the ODFW has released live spring chinook adults above Cougar Reservoir in the McKenzie Subbasin. Cougar Dam is the uppermost extent of natural upstream distribution in the South Fork McKenzie River. Hatchery fish collected from the McKenzie and Willamette hatcheries have been outplanted (Lorz 2000). Since this dam blocks upstream passage of spring chinook, releasing spring chinook above the reservoir to spawn naturally could increase natural production in the South Fork McKenzie River. Studies conducted in 1999 have shown substantial emigration of spring chinook salmon smolts through the turbines and regulating outlets of Cougar Dam. An estimated 15,500 to 18,000 juvenile chinook migrated through the dam (Corps 1999). This suggests that hatchery chinook adults outplanted above Cougar Reservoir spawning successfully and producing natural smolts in the McKenzie Subbasin. Since upstream passage of spring chinook is currently not possible, this strategy is beneficial for natural production in that the historic habitat for spring chinook is being utilized. However, since the available information suggests hatchery fish are producing natural smolts, the use of

Willamette Hatchery stock may adversely affect the indigenous McKenzie spring chinook population to a greater degree when the offspring return as unmarked adults than if McKenzie Hatchery fish were used solely for the outplanting in the subbasin. The strategy appears to be appropriate for increasing natural production in habitat that was historically available. However, surplus McKenzie Hatchery stock would likely be more appropriate for outplanting (Figure 30).

In recent years, fishing in the McKenzie River has been closed. In 2001, the majority of hatchery fish returning to the McKenzie will be externally marked. The ODFW has proposed a selective fishery for marked chinook retention in 2001. This strategy could be beneficial for removing hatchery fish that may spawn in the lower McKenzie, thus reducing the proportion of hatchery fish that spawn naturally.

The last few years, ODFW has been evaluating potential impacts associated with selective fishery on hatchery spring chinook in the Willamette River Basin. Preliminary information suggests the mortality of natural-origin spring chinook under a selective fishery regime in the Lower Willamette would be approximately 3% of the return to the river (Lindsay et al. 1998, 1999). These studies are probably the most accurate estimates of the catch and release mortality of spring chinook because the differential mortality associated with using certain fishing techniques and tackle characteristic of the Willamette fishery were taken into account in the estimates. Given that all hatchery spring chinook have been externally marked since 1996 and the information on catch and release mortality, it appears unlikely that the release of hatchery fish continues to pose a substantial threat to the wild population in the McKenzie Subbasin from being overharvested in fisheries. This assumes that selective fisheries will be implemented as planned.

Hatchery summer steelhead and rainbow trout are also released in the McKenzie Subbasin. Impacts on adult spring chinook from juvenile and adult summer steelhead are likely to be low or non-existent. Summer steelhead smolts are likely to have emigrated from the subbasin before the majority of adult spring chinook return. Summer steelhead adults have a return timing similar to spring chinook. However, any adverse competitive effects on chinook are likely non-existent due to the larger size of chinook and differences in the holding preference of adults (Meehan 1991). If summer steelhead are not harvested and spawn naturally, they could potentially superimpose their redds on spring chinook eggs and fry in the gravel of the stream. Bjornn and Reiser (1991) show similar habitat preferences for redd locations of summer steelhead and spring chinook. However, this potential effect is unquantified and is likely related to the annual abundance of spring chinook and steelhead. Actions are taken to maximize the harvest of summer steelhead and not allow them to spawn naturally. The presence of legal-sized rainbow trout are not likely to affect adult chinook for the same reasons stated above.

The presence of adult summer steelhead and legal sized rainbow promotes recreational fisheries which may catch adult chinook salmon. The effects of these fisheries will be evaluated fully in NMFS' consultation with ODFW on fisheries in the Willamette Basin. However, because of the techniques

used to catch steelhead and rainbow trout and the existing fishing regulations in the McKenzie, anticipated incidental mortality of adult chinook is low.

5.2.5.1.2 Juveniles

The release of juvenile hatchery chinook can also directly and indirectly impact natural-origin chinook that may co-occur in the stream. The effects of the release of juvenile hatchery fish on listed species was fully evaluated in section 5.1. As discussed in section 3 above, most of the natural production of spring chinook in the McKenzie Subbasin occurs upstream of Leaburg Dam. Since the release of smolts occurs from McKenzie Hatchery, which is downstream from Leaburg Dam, the potential for interaction between hatchery fish and natural-origin fish rearing in the stream is greatly reduced. However, during winter and spring, hatchery smolts could co-occur in the stream with natural-origin chinook smolts which are emigrating to the ocean. Since the size of hatchery and natural-origin fish emigrating during this period is relatively similar, predation of hatchery fish on natural-origin smolts is unlikely (Pearson and Fritts 1999). Age-0 fry may be present below Leaburg Dam, where hatchery smolts could predate or compete with the natural-origin fish as they emigrate downstream. Competition or density-dependent effects could occur. However, since the fish are actively moving downstream, it is uncertain if biological resources would be in limited supply. No information was available on the degree of residualism and disease transmission from hatchery to natural-origin chinook in the Willamette Basin. Since hatchery smolts are likely to be in the Lower McKenzie for only a short period of time since they are actively emigrating to the ocean, the effects are probably low.

5.2.5.2 Winter steelhead

The Upper Willamette River steelhead ESU does not include the McKenzie Subbasin (February 16, 2000 FRN 65 7764). Therefore, evaluating the impacts from the proposed actions on winter steelhead is not relevant in the McKenzie Basin.

5.2.6 Middle Fork Willamette Subbasin

5.2.6.1 Spring chinook

As discussed in sections 3 and 4, because most of the historic spawning habitat has been blocked by dams in the Middle Fork Subbasin and recent spawning surveys have shown few spawners in the available habitat below Dexter Dam, a wild population probably does not currently exist in this subbasin. However, because hatchery fish can not be differentiated from natural-origin fish, it is uncertain if natural-origin fish have in fact returned to the collection facility at Dexter Pond in recent years. In 2002, most of the hatchery fish returning to the Middle Fork will be externally marked. This will allow the number of unmarked spring chinook to be quantified. However, these unmarked fish may

be returns from hatchery fry released in the reservoirs and in the Willamette River in previous years.

Based on the available information and current situation of unmarked hatchery fish, impacts from the proposed actions to natural-origin spring chinook in the Middle Fork Subbasin cannot be evaluated. However, it is expected that impacts are zero because a wild population is not likely to exist in this subbasin.

Based on the results observed from outplanting adult spring chinook above Cougar Dam in the McKenzie Subbasin (see section 5.2.5 and Corps 1999). Releasing hatchery chinook that return to the Dexter trap could increase natural production in the streams above the dams that were once accessible to spring chinook. The benefits of this action would be producing offspring which could utilize the currently vacant habitat and supplying juvenile salmonids and the stream ecosystem with additional nutrients from the spawned out chinook carcasses.

An indirect effect on natural-origin adult spring chinook from the release of hatchery spring chinook are the impacts associated with fisheries occurring on the hatchery chinook when they return as adults. In the past, Willamette River hatchery spring chinook have supported popular fisheries with harvest rates in the Lower Willamette River alone being relatively high (Figure 24).

The last few years, ODFW has been evaluating potential impacts associated with selective fishery on hatchery spring chinook in the Willamette River Basin. Preliminary information suggests the mortality of natural-origin spring chinook under a selective fishery regime in the Lower Willamette would be approximately 3% of the return to the river (Lindsay et al. 1998, 1999). These studies are probably the most accurate estimates of the catch and release mortality of spring chinook because the differential mortality associated with using certain fishing techniques and tackle characteristic of the Willamette fishery were taken into account in the estimates. Given that all hatchery spring chinook have been externally marked since 1996 (broodyear 1997) and the information on catch and release mortality, it appears unlikely that the release of hatchery fish would pose a substantial threat to establishing a naturally spawning population in the Middle Fork Willamette Subbasin. This assumes that selective fisheries will be implemented as planned in 2002.

5.2.6.2 Winter steelhead

The Upper Willamette River steelhead ESU does not include the Middle Fork Subbasin (February 16, 2000 FRN 65 7764). Therefore, evaluating the impacts from the proposed actions on winter steelhead is not relevant in the Middle Fork Subbasin.

5.2.7 Coast Fork Subbasin

5.2.7.1 Spring chinook

Two actions have been proposed in the Coast Fork Subbasin: the release of catchable rainbow trout, and the release of live Willamette stock adult hatchery chinook salmon. The available information, as discussed in section 3 above, suggests that natural production of spring chinook is extremely limited or non-existent. Because natural-origin spring chinook are not likely to be present in this subbasin at this time, the proposed actions probably have no effect on listed spring chinook.

5.2.7.2 Winter steelhead

The Upper Willamette River steelhead ESU does not include the Coast Fork Subbasin (February 16, 2000 FRN 65 7764). Therefore, evaluating the impacts from the proposed actions on winter steelhead is not relevant in the Coast Fork Subbasin.

5.2.8 Other Subbasins

No actions relevant to this consultation are proposed in the Upper Willamette, Yamhill, and Tualatin subbasins. Thus, assessing impacts to listed fish in these subbasins is not applicable.

5.2.9 Willamette River and Columbia River migration corridors, and estuary

The above analysis of effects focused on the likely impacts to listed species in the specific subbasins. Below is an assessment of the likely impacts of the proposed actions to listed fish in the mainstem Willamette River, the mainstem Columbia River, estuary, and ocean. Information on the potential impacts from the proposed actions in the ocean is extremely limited. The ocean is not included as critical habitat for Upper Willamette River ESUs (February 16, 2000 65 FRN 7764).

Potential impacts from the release of hatchery fish in the mainstem Willamette and Columbia rivers are primarily due to the interactions of juvenile hatchery and listed, natural-origin fish and the interactions of adult hatchery fish and listed, natural-origin fish.

In the Columbia River Basin, the total release of hatchery fish is limited to 195 million (not including the programs determined to be essential for recovery). This artificial production cap was established to limit the potential adverse effects of having too many hatchery fish interacting with natural-origin fish in the migration corridors (NMFS 1999). All of the artificial production in the Upper Willamette ESUs is included in NMFS' production cap.

Evidence for adverse ecological interactions in the migration corridor/ocean between hatchery fish and natural-origin salmon is limited and equivocal (see section 5.1). Migrational rate information presented

by Dawley et al. (1986) indicates that salmon and steelhead smolt movement through the estuary is quite rapid, on average, three days. Salmon smolts have been shown to travel downstream in the estuary at rates ranging from 1 to >59 km/day for sub-yearling chinook, 5 to >59 km/day for yearling chinook and 12 to >59 km/day for coho (Dawley et al. 1986). The minimal duration of hatchery salmon - natural-origin steelhead overlap due to the rapid movement of steelhead smolts through the estuary diminishes the chances for adverse interactions through competition, predation, and disease transmission. The reduced possibility for adverse interactions in the estuary is supported further by Chapman et al. (1994) who observed that migrating steelhead smolts tend to have an offshore distribution in the estuary and this along with their rapid movement, means that the opportunity for estuarine density-dependent growth depression is less for steelhead than slower migrating summer-migrant species. Another factor minimizes competition in the estuary is that the average size of steelhead smolts in the estuary is approximately 200 mm FL. This is more than 1/3 longer than the average length of coho or chinook yearlings in the estuary (130-180 mm release size) and would suggest different food sources for the larger steelhead than the commingled hatchery salmon smolts (WDFW 1998).

As addressed in Section 5.1, Dawley et al. (1986) reported that movement rates of steelhead through the estuary and into the ocean are accelerated when compared to migration rates observed from release sites to the estuary. They reported that this finding indicates, in general, that the use of the Columbia River estuary by juvenile salmonids originating from upstream areas is limited in duration compared to use documented for other west coast estuaries. Chapman et al. (1994) also reported that steelhead smolts move rapidly through the Columbia River estuary.

The minimal duration of hatchery-natural-origin steelhead overlap due to the rapid movement of steelhead smolts through the estuary diminishes the likelihood for adverse hatchery fish effects through competition, predation, or disease transmission. In evaluating the potential impacts due to competition, Witty et al. (1995) determined that increasing the number of hatchery steelhead in or just upstream of the estuary is unlikely to affect natural populations of anadromous fish. Therefore, the proposed action's adverse effects listed steelhead through interactions within the migration corridor are likely to be minimal.

The release of spring chinook and summer steelhead in the Upper Willamette Basin may affect other listed ESUs as the fish emigrate into the Lower Willamette River and Columbia River. The Willamette River enters the Columbia River at rivermile 101. Given the rates of emigration reported by Dawley et al. (1986), the interaction time between hatchery fish released from the Willamette Basin and other Columbia River listed fish (see Table 2) is likely to be of limited duration. The most adverse effect in the migration corridor would likely result if Willamette River hatchery fish were present when listed fall chinook are emigrating downstream. This is not likely to occur because fall chinook emigrate later in the spring and summer when Willamette hatchery fish would have already migrated downstream.

5.3 Summary of Effects

5.3.1 Upper Willamette spring chinook ESU

The proposed actions are likely to reduce the survival of spring chinook in the Upper Willamette River ESU. All of the subbasins where remnant, naturally spawning spring chinook populations are known to exist (Clackamas, North Santiam, McKenzie) have large artificial propagation programs for spring chinook. These populations have been influenced by hatchery fish spawning naturally to some extent (Nicholas et al. 1995). The best available scientific information suggests that the interbreeding between hatchery and natural-origin chinook can result in modifications to the fitness of wild populations (see section 5.1). This would likely decrease the productivity and genetic integrity of listed Upper Willamette spring chinook (see Appendix B NMFS' draft jeopardy standard).

The impacts to listed spring chinook from the release of hatchery smolts is unquantified but likely to be a low (see Appendix B for the specific ecological interactions considered). This effect of hatchery smolts on natural-origin juvenile fish is likely to be of short duration; the one to four week period of time when the smolts are emigrating to the ocean. In the Clackamas Subbasin most of the hatchery fish are released downstream of where listed juvenile spring chinook would be residing in the stream. Impacts to listed juvenile spring chinook in the McKenzie is likely to also be low because most of the hatchery smolts are released below natural fish rearing areas. However, in the North Santiam River substantial overlap of hatchery and natural-origin juveniles in the stream occurs because hatchery fish are released at Minto dam, which is approximately four miles downstream from the uppermost point of anadromous fish distribution (Big Cliff Dam).

Most of the hatchery production of spring chinook is to mitigate for the significant loss of habitat from the construction of Federal dams in the Willamette Basin. Since the majority of the core spring chinook spawning areas have been lost, it is unknown at this time if the remaining habitat is able to support self-sustaining natural populations of spring chinook. Given the current condition of the remaining habitat it appears unlikely that spring chinook will recover without regaining some of the habitat historically available for natural production.

5.3.2 Upper Willamette winter steelhead ESU

The proposed actions may affect winter steelhead in the Upper Willamette ESU. The only subbasins where actions are proposed and listed steelhead reside is in the Molalla, North Santiam, and South Santiam subbasins. The primary effect of the proposed actions would be the competitive and predatory impacts from hatchery smolts co-occurring in the stream with listed juvenile steelhead. This effect is unquantified. Because of the temporal separation of the return of winter steelhead and hatchery chinook and summer steelhead, impacts to adult steelhead are likely to be minimal or non-existent.

Winter steelhead populations in the Tualatin, Yamhill, Rickreall, Luckiamute, and Calapooia rivers would not likely be affected by the proposed actions. The abundance, productivity, population structure, and genetic diversity of winter steelhead in the Upper Willamette River ESU will not likely be substantially affected by the proposed action (see Appendix B).

5.3.3 Lower Columbia River ESUs

The proposed actions may affect listed chum salmon, chinook salmon, steelhead in the Lower Columbia River ESUs while the hatchery fish are in the mainstem Columbia River. The potential effects to these ESUs are limited to the lower 100 miles of the Columbia River from the mouth of the Willamette River to the estuary. The impacts from the proposed action would likely be from competitive interactions and predation while co-occurring in the mainstem Columbia River. Therefore, the abundance, productivity, population structure, and genetic diversity of the Lower Columbia River ESUs will not likely be substantially affected by the proposed action (see Appendix B).

5.3.4 Middle Columbia River ESUs

The proposed actions may affect steelhead from the Middle Columbia River ESU while the hatchery fish are migrating through the mainstem Columbia River. The potential effects to these ESUs are limited to the lower 100 miles of the Columbia River from the mouth of the Willamette River to the estuary. The impacts from the proposed action would likely be from competitive interactions and predation while co-occurring in the mainstem Columbia River. Therefore, the abundance, productivity, population structure, and genetic diversity of the Middle Columbia River ESU will not likely be substantially affected by the proposed action (see Appendix B).

5.3.5 Upper Columbia River ESUs

The proposed actions may affect listed steelhead and spring chinook from the Upper Columbia River ESUs while the hatchery fish are migrating through the mainstem Columbia River. The potential effects to these ESUs are limited to the lower 100 miles of the Columbia River from the mouth of the Willamette River to the estuary. The impacts from the proposed action would likely be from competitive interactions and predation while co-occurring in the mainstem Columbia River. Therefore, the abundance, productivity, population structure, and genetic diversity of the Upper Columbia River ESUs will not likely be substantially affected by the proposed action (see Appendix B).

5.3.6 Snake River ESUs

The proposed actions may affect listed steelhead, spring/summer chinook, fall chinook, and sockeye from the Snake River Basin ESUs while migrating through the mainstem Columbia River. The potential

effects to these ESUs are limited to the lower 100 miles of the Columbia River from the mouth of the Willamette River to the estuary. The impacts from the proposed action would likely be from competitive interactions and predation while co-occurring in the mainstem Columbia River. Therefore, the abundance, productivity, population structure, and genetic diversity of the Snake River ESUs will not likely be substantially affected by the proposed action (see Appendix B).

6 Cumulative Effects

Cumulative effects are defined as the “effects of future state or private activities, not involving federal activities, which are reasonably certain to occur within the action area of the federal action subject to consultation” (50 CFR 402.02). The action area defined in this consultation includes the entire Willamette River Basin.

The majority of the remaining, core spawning and rearing habitat in the Willamette Basin for spring chinook and winter steelhead is on non-federal lands (private and state owned). Historically and currently, agriculture, livestock grazing, forestry, municipal development, and other activities on non-Federal land have contributed substantially to the temperature and sediment problems in the Willamette Basin (Benner and Sedell 1997; PNERC 1998). Significant improvement in reproductive success of spring chinook and winter steelhead outside of federal land is unlikely without changes in agricultural, forestry, and development occurring within non-Federal riparian areas in the Willamette Basin. NMFS is not aware of any future new (or changes to existing) State and private activities within the action area that would cause greater impacts to listed species than presently occurs. Now that spring chinook and winter steelhead are listed, NMFS assumes that non-Federal land owners will take steps to curtail or avoid future land management practices that would result in the take of this species. In addition, habitat on non-federal land that is affected by forestry and agricultural practices should be better protected in the future due to the State of Oregon’s recovery efforts of anadromous fish under the Willamette Restoration Initiative (Allen et al. 1999).

For actions on non-Federal lands in which the landowner or administering non-Federal agency believes are likely to result in adverse effects to spring chinook, winter steelhead, or their habitat, the landowner or agency should work with NMFS to obtain the appropriate ESA section 10 incidental take permit, which requires submission of a habitat conservation plan. If a take permit is requested, NMFS would likely seek project modifications to avoid or minimize adverse effects and taking of listed fish. However, this is not likely to result in substantial improvement to current habitat conditions because most of the land are small tracts owned by private citizens who are not likely to apply for section 10 permits.

Some improvements in habitat conditions for spring chinook and winter steelhead are expected on Federal lands as a result of Northwest Forest Plan implementation, as guided by ESA consultation.

However, much of the Federal land historically available to anadromous fish is currently inaccessible because of the construction of Federal dams, which blocks or severely hinders upstream passage. It is unlikely that spring chinook will recover to historic levels due to the substantial loss of habitat unless efforts are made to regain access to historic habitat. The recovery potential for winter steelhead is likely to be higher because of their distribution and life history characteristics (i.e. run timing, adult habitat use).

NMFS is currently in consultation with the Corps. on the operation of their 13 flood control dams in the Willamette Basin. NMFS assumes that this consultation will result in stream flows and other habitat conditions that are more beneficial for the survival and recovery of listed fish than in past decades.

7 Conclusions

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined by 50 C.F.R. Part 402 (the consultation regulations). Procedures for conducting consultation under section 7 of the ESA are further described in the Services' Consultation Handbook (USFWS and NMFS 1998). Jeopardy is defined as to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. NMFS' draft jeopardy standard for hatchery programs is detailed in Appendix B.

Determining whether the proposed actions jeopardizes the survival and recovery of listed species, in particular the Upper Willamette River ESUs, is difficult because of the limited information on the actual abundance and distribution of natural-origin spring chinook and steelhead. In addition, the proposed actions have essentially been occurring over the last 20 to 30 years. Because of this, it is extremely difficult to separate the effects of the hatchery programs from other human and natural factors contributing to the current status of the ESUs. However, even though there are many uncertainties in the actual impacts of the proposed actions, the conclusions reached in this Opinion erred on the side of conserving and recovering the listed species in the Upper Willamette River ESUs.

With respect to the effects of hatchery programs on listed species, the time period over which the actions are evaluated is critical for determining jeopardy. Given the above analysis of effects, if the hatchery programs were only evaluated over a short period of time (1-10 years) in the future, significantly different conclusions could be reached than if the hatchery program was evaluated over a longer period of time (10 to 50 years; see Figure 31 as an example). Since the hatchery programs were in existence in the past and are likely to be ongoing in some fashion in the future, the long-term effects of artificial propagation were considered in the jeopardy determination. The effects of the proposed actions were considered over a longer period of time (i.e. >10 years).

The above analysis of effects has demonstrated the proposed actions will likely result in changes in the abundance, productivity, population structure, and/or genetic integrity of the Upper Willamette River spring chinook and winter steelhead ESUs. It is the conclusion of NMFS that the hatchery programs as described in the proposed actions appreciably reduces the survival *and* recovery of listed spring chinook and thus, jeopardizes the continued existence of the Upper Willamette spring chinook ESU. See NMFS' draft jeopardy standard in Appendix B for further information on the specific biological factors considered in the jeopardy determination. NMFS has determined that the proposed actions do not appreciably reduce the survival and recovery of listed winter steelhead and thus, do not jeopardize the continued existence of the Upper Willamette River winter steelhead ESU. The proposed actions will not result in the destruction or adverse modification of critical habitat for the listed Upper Willamette River ESUs. NMFS determined that the proposed actions covered in this consultation do not jeopardize the continued existence or result in adverse modification of critical habitat for the following listed ESUs: Lower Columbia River chinook and steelhead, Columbia River chum, Middle Columbia River steelhead, Snake River spring/summer chinook, fall chinook, steelhead, and sockeye, and Upper Columbia River spring chinook and steelhead.

8 Reasonable and Prudent Alternative

Regulations (50 CFR §402.02) implementing section 7 of the Act define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, NMFS believes, avoid the likelihood of jeopardizing the continued existence of listed salmon and steelhead or result in the destruction or adverse modification of critical habitat.

The reasonable and prudent alternative contained in this Opinion identify measures that will avoid jeopardy of the Upper Willamette River spring chinook ESU. The measures remove jeopardy on listed spring chinook in the Upper Willamette by: 1) immediately reducing the number of hatchery fish spawning naturally; 2) modifying the numbers and release locations of hatchery fish to reduce adverse ecological effects; 3) development of locally adapted hatchery stocks; and 4) facilitating the identification of hatchery- and naturally-produced fish. These reasonable and prudent alternative consist of the following changes from the proposed action:

1. The action agencies shall reduce the natural spawning of hatchery-origin spring chinook with existing natural spring chinook salmon populations.
 - a. Clackamas Subbasin
 - i. The straying of hatchery spring chinook above River Mill or North Fork Dams

on the Clackamas River shall be restricted to reduce genetic and ecological risks associated with hatchery fish spawning in the wild. The NMFS, ODFW, City of Portland, and PGE (agencies funding production) shall develop plans and methods to capture and remove known hatchery chinook so that they do not spawn naturally.

- ii. The agencies currently working on plans to retrofit Clackamas River dam(s) shall request facilities which, to the extent possible, minimize impacts to natural-origin chinook from the sorting of hatchery fish.
- iii. In 2002, when most returning hatchery spring chinook will be externally marked, the action agencies shall limit access of hatchery chinook to the extent possible above North Fork Dam. No more than 30% of the fish passed upstream shall be hatchery spring chinook. If the abundance of unmarked spring chinook passing North Fork Dam annually is projected to be less than 500 fish, the action agencies must confer with NMFS' Hatcheries and Inland Fisheries Branch, Portland, Oregon, on the percentage of hatchery fish that could be allowed to migrate past North Fork Dam and spawn naturally.
- iv. The release of McKenzie Hatchery spring chinook stock in the lower Clackamas River shall be eliminated to reduce the potential straying and spawning of non-local stock in the Clackamas Subbasin. The production should be replaced with spring chinook returning to the Clackamas Subbasin and/or Clackamas Hatchery.

b. North Santiam Subbasin

- i. In 2001 and beyond when most fish returning will be marked, the number of natural-origin (unmarked) spring chinook collected for broodstock at Minto Pond shall be limited to less than 10% of the annual broodstock goal (600 fish) for Marion Forks Hatchery. All natural-origin chinook in excess of this limit shall be released back into the wild to spawn naturally.

c. McKenzie Subbasin

- i. The straying of hatchery spring chinook above Leaburg Dam on the McKenzie River shall be restricted to reduce genetic and ecological risks associated with hatchery fish spawning in the wild. The Corps and ODFW shall develop plans and methods to capture and remove known hatchery chinook so that they do

not spawn naturally.

- ii. The Corps, ODFW, and Eugene Water and Electric Board currently working on developing plans to improve the Leaburg Dam trapping facility shall develop facilities which, to the extent possible, minimize impacts to natural-origin chinook from the sorting of hatchery fish.
 - iii. In 2001 and beyond, when most returning hatchery spring chinook will be externally marked, the Corps and ODFW shall remove hatchery chinook to the greatest extent possible at Leaburg Dam. If the abundance of unmarked spring chinook passing Leaburg Dam annually is projected to be less than 700 fish, the action agencies must confer with NMFS' Hatcheries and Inland Fisheries Branch, Portland, Oregon, on the percentage of hatchery fish that could be allowed to migrate past Leaburg Dam and spawn naturally.
 - iv. ODFW shall terminate all releases of surplus adult hatchery spring chinook from non-McKenzie River hatchery stock into the McKenzie Subbasin. In recent years, hatchery chinook from the Middle Fork Willamette Subbasin have been outplanted to spawn naturally in the McKenzie Subbasin.
2. The action agencies shall facilitate differentiation between hatchery-origin and natural-origin fish.
- a. The action agencies shall provide funding and mark (externally, or internally for research purposes) all artificially-produced fish released into waters within the geographic range of the spring chinook and winter steelhead ESUs. This will allow hatchery spring chinook, steelhead, and trout to be distinguished from naturally-produced, listed fish.
 - b. ODFW shall eliminate the release of all unmarked juvenile hatchery fish (unfed fry, fingerling) in waters likely containing listed spring chinook and winter steelhead.

9 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. NMFS believes the following conservation recommendations are consistent with these obligations, and therefore should be implemented by the action agencies.

9.1 All Agencies

1. The action agencies should fund and/or continue to collaboratively develop Hatchery and Genetic Management Plans (HGMPs) for hatchery programs in the Upper Willamette River spring chinook and winter steelhead ESUs. HGMPs should be finalized before September 30, 2003 (the end of this consultation period). Development of HGMPs for spring chinook should be the highest priority.
2. The action agencies should develop distinguishable marks (or a representative sample) for hatchery spring chinook within each of the subbasins. Distinguishable marks will allow assessment of the development of locally-adapted stocks and aid in the evaluation of inter-basin straying of hatchery fish.
3. The action agencies should develop production plans that minimize transfers of fish among hatcheries for rearing. Reducing the transfer of juvenile hatchery among subbasins will likely improve homing fidelity and reduce interbasin straying of hatchery fish.
4. The appropriate action agencies should consider relocating some of the mitigation hatchery production to Lower Columbia River “select areas.” This should provide greater utilization of hatchery production and reduce the number of surplus fish returning to hatcheries in the Willamette Basin.

9.2 Agency Specific

1. The Corps should develop contingency plans with the appropriate agency(s) on production goals (and release strategies) if future monitoring and evaluation suggests hatchery mitigation is not being utilized in fisheries and the percentage of hatchery fish on the spawning grounds is high. The contingency plans must clearly demonstrate the benefits to natural populations of spring chinook and winter steelhead in the Upper Willamette River ESUs.
2. The ODFW should recycle adult hatchery (of known origin) salmon and steelhead captured at hatchery facilities within the Willamette River Basin to promote the maximum harvest of hatchery fish in recreational fisheries and reduce the number of surplus fish at the end of the season. Hatchery fish should be recycled only within the subbasin in which the fish were captured and downstream from the hatchery facility. Recycling shall be terminated if the fish would likely spawn naturally or when fishing is not likely to result in the harvest of the recycled fish.

10 Incidental Take Statement

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by both FWS and NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by both FWS and NMFS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limit to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be undertaken by the agencies so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The agencies have a continuing duty to regulate the activity covered by this incidental take statement. If the agencies (1) fail to assume and implement the terms and conditions or (2) fail to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the agencies or applicant must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize impacts and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures.

10.1 Amount or Extent of Take

The proposed actions are expected to result in the incidental take of listed salmon and steelhead in the Columbia River Basin. Because of the inherent biological characteristics of aquatic species such as listed salmon and steelhead, the dimensions and variability of the river systems, and the operational complexities of hatchery actions, determining precise (or even quantifiable) levels of mortality for juveniles and adults attributable to the proposed actions are difficult or not possible at the present time.

The collection of listed adult spring chinook salmon for hatchery broodstock in the Upper Willamette

River ESU is likely to be low when returning adults are all marked. However, based on the best available science incorporating natural-origin chinook into hatchery broodstocks could reduce the risks associated with artificial propagation programs (see section 5). The incidental catch of listed winter steelhead in hatchery collection facilities covered in this Opinion is likely to be low or non-existent (winter steelhead collections at Clackamas Hatchery are addressed in the biological opinion for the Lower Columbia River steelhead ESU). Since no winter steelhead are taken for hatchery programs, the fish will be released back into the wild unharmed.

An incidental take of listed juvenile winter steelhead and spring chinook from the Upper Willamette River ESUs is also expected to occur from the release of juvenile hatchery fish. Since the incidental take from these releases are limited primarily to mainstem migration corridors, the estuary, and ocean, quantifying the level of take is difficult. In the absence of exact numbers of listed salmon and steelhead expected to be taken from juvenile hatchery fish releases, NMFS has relied on a qualitative analysis to determine the consistency of the proposed actions with that of the Proposed Recovery Plan for Snake River Basin salmon (NMFS 1995X) and the risk assessment. However, this qualitative assessment does not provide quantitative estimates. In the absence of quantitative estimates of other incidental take, NMFS will monitor release numbers and locations, and broodstock collection to monitor compliance with the following reasonable and prudent measures and terms and conditions.

10.2 Reasonable and Prudent Measures

The following reasonable and prudent measures are provided to minimize and reduce the anticipated level of incidental take associated with all the agencies artificial propagation programs:

1. All action agencies shall provide projected hatchery fish releases for the coming year to NMFS, Hatcheries and Inland Fisheries Branch, Portland, Oregon, by December 15, of the current year.
2. All action agencies shall manage their programs to minimize the potential interbreeding of hatchery fish and listed salmon and steelhead in the Columbia River Basin.
3. All action agencies shall quantify the effects of hatchery broodstock collection on listed spring chinook and winter steelhead in the Upper Willamette River ESUs.
4. All action agencies shall minimize potential negative impacts to listed salmon and steelhead in the Upper Willamette River Basin from operation of their respective artificial propagation facilities.
5. All action agencies shall monitor and evaluate their respective artificial propagation programs in

the Upper Willamette River Basin.

10.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the action agencies (Corps, NMFS, BPA, ODFW, PGE, City of Portland) must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary. All required information and reports shall be mailed to NMFS, Hatcheries and Inland Fisheries Branch, 525 NE Oregon Street Suite 510, Portland, Oregon 97232.

- 1a. All action agencies shall update and provide to NMFS, Hatcheries and Inland Fisheries Branch, 525 NE Oregon Street, Suite 510, Portland Oregon 97232, by December 15 of each year this Biological Opinion is in force, the projected hatchery releases for the coming year. This information will be used to determine if total releases will remain within the production ceiling established for the Columbia Basin. Annual release of anadromous fish not used for recovery purposes in the Columbia River Basin is limited to approximately 197.4 million (of which 20.2 million are in the Snake River Basin) until the HGMP's are completed and justification can be provided to modify production.
- 2a. The action agencies shall reduce the number of hatchery spring chinook spawning above North Fork Dam on the Clackamas River and Leaburg Dam on the McKenzie River, as specified in the Reasonable and Prudent Alternatives section above.
- 2b. The action agencies shall externally mark their respective production obligations of spring chinook, steelhead, and resident trout covered in this consultation. This will facilitate identification of the percentage of listed and non-listed fish on the spawning grounds, in hatchery broodstocks, and in the fisheries catch.
- 2c. Surplus hatchery salmon and steelhead shall not be outplanted to spawn naturally in areas currently accessible to listed fish in the Clackamas Subbasin, North Santiam Subbasin, or McKenzie Subbasin. Outplanting of jack and adult spring chinook can occur in the North Santiam Subbasin above Detroit Dam (from fish collected at Minto), Middle Fork (from fish collected at Dexter), Coast Fork (from fish collected at Dexter), South Santiam (from fish collected at Foster), Molalla (from fish collected at Foster), and Calapooia (from fish collected at Foster) subbasins. All others must be approved before outplanting by NMFS, Hatcheries and Inland Fisheries Branch, 525 NE Oregon Street Suite 510, Portland, Oregon 97232.
- 2d. The action agencies shall monitor the straying of hatchery fish on natural spawning grounds. The action agencies shall conduct annually spawning surveys for spring chinook to determine

the abundance and distribution of hatchery and natural-origin fish in the Upper Willamette River ESU. Intensive surveys shall be conducted in at least the Clackamas, North Santiam, and McKenzie rivers to determine the distribution, abundance and proportion of hatchery fish on the spawning grounds. For the spawning surveys, the action agencies shall provide funding in proportion to their respective funding obligations for the artificial propagation programs.

- 3a. The action agencies shall record the number of marked and unmarked fish that volitionally enter the hatcheries and broodstock collection facilities beginning in 2000. In 2002, when the majority of hatchery spring chinook returns will be externally marked, the action agencies shall determine the number and percentage of fish captured that are unmarked, naturally-produced fish. If the percentage of unmarked fish is greater than 10% of total fish captured over the trapping season (excluding the traps at North Fork and Leaburg dams), the action agencies must notify NMFS, Hatcheries and Inland Fisheries Branch, 525 NE Oregon Street Suite 510, Portland, Oregon 97232 before spawning the fish. Natural-origin fish may be released back into the wild unharmed.
- 3b. Beginning in 2002, the action agencies shall determine the number and percentage of the natural-origin (unmarked) spring chinook run that are taken annually for broodstock purposes. The percentage of natural-origin fish taken should be calculated from the actual run at Willamette Falls and the estimated or actual return to the subbasins (i.e. Clackamas, North Santiam, McKenzie). If the percentage of the natural-origin spring chinook run taken for broodstock is (or likely to be) greater than 10%, the appropriate agency(s) must notify NMFS, Hatcheries and Inland Fisheries Branch, 525 NE Oregon Street Suite 510, Portland, Oregon 97232 as soon as possible. Natural-origin fish may be released back into the wild unharmed.
- 3c. Beginning with brood year 2002, all hatchery fish releases into areas outside of the Upper Willamette River ESUs (i.e. Lower Columbia River “select areas”) shall be of known hatchery x hatchery crosses. No progeny of wild x wild or hatchery x wild adult crossed fish shall be released outside of the Willamette River Basin.
- 3d. The action agencies shall not transfer any hatchery broodstock into hatchery programs in other subbasins.
- 3e. The action agencies shall minimize the potential of capturing natural-origin winter steelhead in hatchery and/or trapping facilities. This term and condition does not apply to the intentional capturing of winter steelhead associated with any trap and haul efforts (e.g. at Foster Dam). In the event a listed winter steelhead is captured, the fish should be handled to minimize stress and injury and released promptly back into the wild unharmed.

- 4a. The action agencies shall operate the hatchery and any other broodstock trapping facilities to encompass the entire run timing and age and size distribution of spring chinook in a particular subbasin. The broodstock shall be selected at random from among the fish collected. The number of spring chinook spawned should be in proportion to their spawn timing. This should minimize the effects of selecting a particular fish size or spawn timing in the broodstock.
- 4b. The action agencies shall release hatchery fish that will actively emigrate downstream. Hatchery fish releases shall be volitional to the extent possible.
- 4c. The appropriate agencies shall release the non-acclimated group of hatchery spring chinook (488 K) at multiple locations in the North Santiam River to reduce the potential ecological effects on listed juvenile fish. The release locations should be dispersed along the North Santiam River to the extent possible above the confluence of the Little North Santiam River.
- 4d. The Corps shall monitor the effects of the hatchery rainbow stocking in the McKenzie Subbasin on listed spring chinook. A creel survey shall be conducted for at least one season to determine the bycatch of listed juvenile and adult spring chinook in recreational fisheries targeting trout.
- 4e. The appropriate agencies shall fund and/or monitor the effects of the non-native summer steelhead program in the North and South Santiam and McKenzie rivers for at least two years. An estimate of the percentage of the summer steelhead run that is harvested and/or the number of summer steelhead potentially spawning naturally in the streams shall be determined.
- 4f. The action agencies shall ensure that water intakes into artificial propagation facilities are properly screened using NMFS (1995) screening criteria to prevent listed salmon and steelhead from entering. All action agencies shall inspect the water intake screen structures at the hatchery facilities they fund to determine if listed salmon and steelhead are being drawn into the facility or being impinged. Improvements to the structures shall be made where necessary.
- 5a. The action agencies shall continue to comply with reporting requirements and protocols and guidelines established by the Integrated Hatchery Operations Team (IHOT 1995; 1996) for Columbia Basin hatcheries.
- 5b. The action agencies shall comply with existing National Discharge and Elimination System (NPDES) permits governing water quality from hatchery effluents.
- 5c. The action agencies shall record the date, number, length, and sex of spring chinook spawned, specified by hatchery and naturally-produced fish.

- 5d. If an ESA-listed fish mortality event occurs from the proposed actions (>10% mortality in one event), the appropriate agency(s) must inform the NMFS, Hatcheries and Inland Fisheries Branch, 525 NE Oregon Street Suite 510, Portland, Oregon 97232, of such event within three days. Details of the cause of mortality and actions or plans taken to remedy the situation must also be supplied.
- 5e. The appropriate action agencies shall conduct creel surveys to monitor and evaluate the bycatch of listed steelhead and spring chinook in the Foster Reservoir trout fishery. The surveys shall be conducted for at least two fishing seasons.
- 5f. The Corps and ODFW shall evaluate the risks and benefits to listed chinook salmon from the outplanting hatchery spring chinook above Cougar Reservoir in the McKenzie Subbasin. The returning progeny from these hatchery adult outplants will be undistinguishable from the indigenous, non-hatchery lineage of spring chinook in the McKenzie River. The likelihood of adverse effects to the indigenous chinook population from the adult hatchery fish outplants needs to be assessed.

11 Reinitiation Of Consultation

This concludes formal consultation on the proposed actions. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the biological opinion; (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, the action agency must immediately reinitiate formal consultation.

The issuance of section 10 permits (as discussed in section 1.2) to non-Federal agencies for hatchery program operations once take prohibitions go into effect does not warrant reinitiation of consultation, as long as the conditions listed in the above paragraph are not met.

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APPENDIX A

BIOLOGICAL REQUIREMENTS, STATUS, AND TRENDS: SNAKE RIVER SPRING/SUMMER, SNAKE RIVER FALL, UPPER COLUMBIA RIVER SPRING, UPPER WILLAMETTE RIVER, AND LOWER COLUMBIA RIVER CHINOOK SALMON; SNAKE RIVER, UPPER COLUMBIA RIVER, MIDDLE COLUMBIA RIVER, UPPER WILLAMETTE RIVER, AND LOWER COLUMBIA RIVER STEELHEAD; COLUMBIA RIVER CHUM SALMON; AND SNAKE RIVER SOCKEYE SALMON

Table 1. Summary of salmon species listed and proposed for listing under the Endangered Species Act.

Species	Evolutionarily Significant Unit	Present Status	Federal Register Notice	
Chinook Salmon (<i>O. tshawytscha</i>)	Sacramento River Winter	Endangered	59 FR 440	1/4/94
	Snake River Fall	Threatened	57 FR 14653	4/22/92
	Snake River Spring/Summer	Threatened	57 FR 14653	4/22/92
	Central Valley Spring	Threatened	64 FR 50393	9/16/99
	California Coastal	Threatened	64 FR 50393	9/16/99
	Puget Sound	Threatened	64 FR 14308	3/24/99
	Lower Columbia River	Threatened	64 FR 14308	3/24/99
	Upper Willamette River	Threatened	64 FR 14308	3/24/99
	Upper Columbia River Spring	Endangered	64 FR 14308	3/24/99
Chum Salmon (<i>O. keta</i>)	Hood Canal Summer-Run	Threatened	64 FR 14508	3/25/99
	Columbia River	Threatened	64 FR 14508	3/25/99
Coho Salmon (<i>O. kisutch</i>)	Central California Coastal	Threatened	61 FR 56138	10/31/96
	S. Oregon/ N. California Coastal	Threatened	62 FR 24588	5/6/97
	Oregon Coastal	Threatened	63 FR 42587	8/10/98
Sockeye Salmon (<i>O. nerka</i>)	Snake River	Endangered	56 FR 58619	11/20/91
	Ozette Lake	Threatened	64 FR 14528	3/25/99
Steelhead (<i>O. mykiss</i>)	Southern California	Endangered	62 FR 43937	8/18/97
	South-Central California	Threatened	62 FR 43937	8/18/97
	Central California Coast	Threatened	62 FR 43937	8/18/97
	Upper Columbia River	Endangered	62 FR 43937	8/18/97
	Snake River Basin	Threatened	62 FR 43937	8/18/97
	Lower Columbia River	Threatened	63 FR 13347	3/19/98
	California Central Valley	Threatened	63 FR 13347	3/19/98
	Upper Willamette River	Threatened	64 FR 14517	3/25/99
	Middle Columbia River	Threatened	64 FR 14517	3/25/99
Cutthroat Trout Sea-Run (<i>O. clarki clarki</i>)	Umpqua River	Endangered	61 FR 41514	8/9/96
	Southwest Washington/Columbia River	Proposed Threatened	64 FR 16397	4/5/99

Table 2. Summary of critical habitat designations under the Endangered Species Act.

Species	Evolutionarily Significant Unit	Federal Register Notice	
Chinook Salmon (<i>O. tshawytscha</i>)	Sacramento River Winter	58 FR 33212	6/16/93
	Snake River Fall	58 FR 68543	12/28/93
	Snake River Spring/Summer	58 FR 68543	12/28/93
	Revised:	64 FR 57399	10/25/99
	Central Valley Spring	65 FR 7764	3/9/98
	California Coastal	65 FR 7764	3/9/98
	Puget Sound	65 FR 7764	2/16/00
	Lower Columbia River	65 FR 7764	2/16/00
	Upper Willamette River	65 FR 7764	2/16/00
	Upper Columbia River Spring	65 FR 7764	2/16/00
Chum Salmon (<i>O. keta</i>)	Hood Canal Summer-Run	65 FR 7764	2/16/00
	Columbia River	65 FR 7764	2/16/00
Coho Salmon (<i>O. kisutch</i>)	Central California Coastal	64 FR 24049	5/5/99
	S. Oregon/ N. California Coastal	64 FR 24049	5/5/99
	Oregon Coastal	65 FR 7764	2/16/00
Sockeye Salmon (<i>O. nerka</i>)	Snake River	58 FR 68543	12/28/93
	Ozette Lake	65 FR 7764	2/16/00
Steelhead (<i>O. mykiss</i>)	Southern California	65 FR 7764	2/16/00
	South-Central California	65 FR 7764	2/16/00
	Central California Coast	65 FR 7764	2/16/00
	Upper Columbia River	65 FR 7764	2/16/00
	Snake River Basin	65 FR 7764	2/16/00
	Lower Columbia River	65 FR 7764	2/16/00
	California Central Valley	65 FR 7764	2/16/00
	Upper Willamette River	65 FR 7764	2/16/00
Cutthroat Trout Sea-Run (<i>O. clarki clarki</i>)	Umpqua River	63 FR 1388	1/9/98
	Southwest Washington/Columbia River	none proposed	

II. Status of the Species and Critical Habitat

Note: the essential features of the critical habitat include, but are not limited to: (1) spawning and rearing areas and migration corridors between these areas, (2) food resources, (3) water quality and quantity, (4) riparian vegetation. The NMFS has not designated marine areas, as critical habitat, even though they may fall within some specific action areas.

A. Species Descriptions and Critical Habitat Designations

1. Chinook Salmon

Snake River Spring/Summer Chinook Salmon

The SR spring/summer chinook salmon ESU, listed as threatened on April 22, 1992 (67 FR 14653), includes all natural-origin populations in the Tucannon, Grande Ronde, Imnaha, and Salmon rivers. Some or all of the fish returning to several of the hatchery programs are also listed including those returning to the Tucannon River, Imnaha, and Grande Ronde hatcheries, and to the Sawtooth, Pahsimeroi, and McCall hatcheries on the Salmon River. Critical habitat was designated for SR spring/summer chinook salmon on December 28, 1993 (58 FR 68543) and was revised on October 25, 1999 (64 FR 57399).

Snake River Fall Chinook Salmon

The SR fall chinook salmon ESU, listed as threatened on April 22, 1992 (67 FR 14653), includes all natural-origin populations of fall chinook in the mainstem Snake River and several tributaries including the Tucannon, Grande Ronde, Salmon, and Clearwater rivers. Fall chinook from the Lyons Ferry Hatchery are included in the ESU but are not listed.. Critical habitat was designated for SR fall chinook salmon on December 28, 1993 (58 FR 68543).

Upper Columbia River Spring-Run Chinook Salmon

The UCR spring-run chinook salmon ESU, listed as endangered on March 24, 1999 (64 FR 14308), includes all natural-origin stream-type chinook salmon from river reaches above Rock Island Dam and downstream of Chief Joseph Dam, including the Wenatchee, Entiat, and Methow River basins. All chinook in the Okanogan River are apparently ocean-type and are considered part of the Upper Columbia River Summer-and Fall-run ESU. The spring-run components of the following hatchery stocks are also listed: Chiwawa, Methow, Twisp, Chewuch, and White rivers, and Nason Creek. Critical habitat was designated for UCR spring chinook salmon on December 28, 1993 (58 FR 68543).

Upper Willamette River Chinook Salmon

The UWR chinook salmon ESU, listed as threatened on March 24, 1999 (64 FR 14308), occupies the Willamette River and tributaries upstream of Willamette Falls, in addition to naturally produced spring-run fish in the Clackamas River. Upper Willamette spring chinook salmon are one of the most genetically distinct chinook groups in the Columbia River Basin. Fall chinook salmon spawn in the Upper Willamette but are not considered part of the ESU because they are not native. None of the hatchery populations in the Willamette River were listed although five spring-run hatchery stocks were included in the ESU. Critical habitat was designated for UWR chinook salmon on February 16, 2000 (58 FR 68543).

Lower Columbia River Chinook Salmon

The LCR chinook salmon ESU, listed as threatened on March 24, 1999 (64 FR 14308), includes all natural-origin populations of both spring- and fall-run chinook salmon in tributaries to the Columbia River from a transition point located east of the Hood River, Oregon, and the White Salmon River, Washington, to the mouth of the Columbia River at the Pacific Ocean and in the Willamette River below Willamette Falls, Oregon (excluding spring chinook salmon in the Clackamas River). Not included in this ESU are “stream-type” spring-run chinook salmon found in the Klickitat River (which are considered part of the Mid-Columbia River Spring-Run ESU) or the introduced Carson spring-chinook salmon strain. “Tule” fall chinook salmon in the Wind and Little White Salmon rivers are included in this ESU, but not introduced “upriver bright” fall-chinook salmon populations in the Wind, White Salmon, and Klickitat rivers. The Cowlitz, Kalama, Lewis, Washougal, and White Salmon rivers, constitute the major systems on the Washington side; the lower Willamette and Sandy Rivers are foremost on the Oregon side. The majority of this ESU is represented by fall-run fish; there is some question whether any natural-origin spring chinook salmon persist in this ESU. Fourteen hatchery stocks were included in the ESU; one was considered essential for recovery (Cowlitz River spring chinook) but was not listed. Critical habitat was designated for LCR chinook salmon on February 16, 2000 (65 FR 7764).

2. Steelhead

Upper Columbia River Steelhead

The UCR steelhead ESU, listed as endangered on August 18, 1997 (62 FR 43937), includes all natural-origin populations of steelhead in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S./Canada Border the Yakima River. The Wells Hatchery stock is included among the listed populations. Critical habitat was designated for UCR steelhead on February 16, 2000 (65 FR 7764).

Snake River Steelhead

The SR steelhead ESU, listed as threatened on August 18, 1997 (62 FR 43937), includes all natural-origin populations of steelhead in the Snake River Basin of Southeast Washington, northeast Oregon,

and Idaho. None of the hatchery stocks in the Snake River Basin are listed, but several are included in the ESU. Critical habitat was designated for SR steelhead on February 16, 2000 (65 FR 7764).

Middle Columbia River Steelhead

The MCR steelhead ESU, listed as threatened on March 25, 1999 (64 FR 14517), includes all natural-origin populations in the Columbia River Basin above the Wind River, Washington, and the Hood River, Oregon, including the Yakima River, Washington. This ESU includes the only populations of winter inland steelhead in the United States (in the Klickitat River, Washington, and Fifteenmile Creek, Oregon). Both the Deschutes River and Umatilla River hatchery stocks are included in the ESU, but are not listed. Critical habitat was designated for MCR steelhead on February 16, 2000 (65 FR 7764).

Upper Willamette River Steelhead

The UWR steelhead ESU, listed as threatened on March 25, 1999 (64 FR 14517), is comprised of all natural-origin populations in the Willamette River and its tributaries upstream of Willamette Falls to the Calapooia River, inclusive. None of the hatchery stocks were included as part of the listed ESU. Critical habitat was designated for UWR steelhead on February 16, 2000 (65 FR 7764).

Lower Columbia River Steelhead

The LCR steelhead ESU, listed as threatened on March 19, 1998 (63 FR 13347), is comprised of all natural-origin populations in tributaries to the Columbia River between the Cowlitz and Wind rivers, Washington, and the Willamette and Hood rivers, Oregon, inclusive. The NMFS specifically excluded three river basins: (1) the Willamette River basin above Willamette Falls, (2) the Little White Salmon River, and the Big White Salmon River, Washington (61 FR 41545). Among hatchery stocks, late-spawning Cowlitz River Trout Hatchery and late-spawning Clackamas River ODFW stock #122 are part of the ESU but are not considered essential for recovery. Critical habitat was designated for LCR steelhead on February 16, 2000 (65 FR 7764).

3. Chum Salmon

Columbia River Chum Salmon

The CR chum salmon ESU, listed as threatened on March 25, 1999 (64 FR 14508), includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. None of the hatchery populations are included as part of the listed ESU. Critical habitat was designated for CR chum salmon on February 16, 2000 (65 FR 7764).

4. Sockeye Salmon

Snake River Sockeye Salmon

The SR sockeye salmon ESU, listed as endangered on November 20, 1991 (56 FR 58619), includes populations of sockeye salmon from the Snake River basin, Idaho (extant populations occur only in the Stanley River subbasin). Under NMFS' interim policy on artificial propagation (58 FR 17573), the progeny of fish from a listed population that are propagated artificially are considered part of the listed species and are protected under the ESA. Thus, although not specifically designated in the 1991 listing, SR sockeye salmon produced in the captive broodstock program are included in the listed ESU. Given the dire status of the wild population under any criteria (a total of 23 wild fish returned to Redfish Lake during the 10-year period 1990 through 1999), NMFS considers the captive broodstock and its progeny essential for recovery. Critical habitat was designated for SR sockeye salmon on December 28, 1993 (58 FR 68543).

B. General Life Histories**1. Chinook Salmon**

Chinook salmon is the largest of the Pacific salmon. The species' distribution historically ranged from the Ventura River in California to Point Hope, Alaska, in North America, and in northeastern Asia from Hokkaido, Japan, to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970). Of the Pacific salmon, chinook salmon exhibit arguably the most diverse and complex life history strategies. Healey (1986) described 16 age categories for chinook salmon, 7 total ages with 3 possible freshwater ages. This level of complexity is roughly comparable to that seen in sockeye salmon (*O. nerka*), although the latter species has a more extended freshwater residence period and uses different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon, which reside in freshwater for a year or more following emergence, and "ocean-type" chinook salmon, which migrate to the ocean within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. Healey's approach incorporates life history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations.

The generalized life history of Pacific salmon involves incubation, hatching, and emergence in freshwater; migration to the ocean; and the subsequent initiation of maturation and return to freshwater for completion of maturation and spawning. The juvenile rearing period in freshwater can be minimal or extended. Additionally, some male chinook salmon mature in freshwater, thereby foregoing emigration to the ocean. The timing and duration of each of these stages is related to genetic and environmental determinants and their interactions to varying degrees. Although salmon exhibit a high degree of variability in life-history traits, there is considerable debate as to what degree this variability is shaped by local adaptation or results from the general plasticity of the salmonid genome (Ricker 1972, Healey 1991, Taylor 1991). More detailed descriptions of the key features of chinook salmon life history can

be found in Myers et al. (1998) and Healey (1991).

2. Steelhead

Steelhead can be divided into two basic run-types based on the state of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns shortly after river entry (Barnhart 1986). Variations in migration timing exist between populations. Some river basins have both summer and winter steelhead, whereas others only have one run-type.

In the Pacific Northwest, summer steelhead enter fresh water between May and October (Busby et al. 1996; Nickelson et al. 1992). During summer and fall, prior to spawning, they hold in cool, deep pools (Nickelson et al. 1992). They migrate inland toward spawning areas, overwinter in the larger rivers, resume migration in early spring to natal streams, and then spawn (Meehan and Bjornn 1991; Nickelson et al. 1992). Winter steelhead enter fresh water between November and April in the Pacific Northwest (Busby et al. 1996; Nickelson et al. 1992), migrate to spawning areas, and then spawn in late winter or spring (et al. 1992a). Some adults, however, do not enter coastal streams until spring, just before spawning (Meehan and Bjornn 1991). Difficult field conditions (snowmelt and high stream flows) and the remoteness of spawning grounds contribute to the relative lack of specific information on steelhead spawning.

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death. However, it is rare for steelhead to spawn more than twice before dying and most that do so are females (Nickelson et al. 1992). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Multiple spawnings for steelhead range from 3% to 20% of runs in Oregon coastal streams.

Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986; Everest 1973). Steelhead enter streams and arrive at spawning grounds weeks or even months before they spawn and are vulnerable to disturbance and predation. Cover, in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity (Giger 1973) are required to reduce disturbance and predation of spawning steelhead. Summer steelhead usually spawn further upstream than winter steelhead (Withler 1966; Behnke 1992).

Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (August 9, 1996, 61 FR 41542) before hatching. Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Some older juveniles move

downstream to rear in larger tributaries and mainstem rivers (Nickelson et al. 1992).

Juveniles rear in fresh water from one to four years, then migrate to the ocean as smolts. Winter steelhead populations generally smolt after two years in fresh water (Busby et al. 1996). Steelhead typically reside in marine waters for two or three years prior to returning to their natal stream to spawn at four or five years of age. Populations in Oregon and California have higher frequencies of age-1-ocean steelhead than populations to the north, but age-2-ocean steelhead generally remain dominant (Busby et al. 1996). Age structure appears to be similar to other west coast steelhead, dominated by four-year-old spawners (Busby et al. 1996).

Based on purse seine catches, juvenile steelhead tend to migrate directly offshore during their first summer rather than migrating along the coastal belt as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986). Oregon steelhead tend to be north-migrating (Nicholas and Hankin 1988; Pearcy et al. 1990; Pearcy 1992).

3. Chum Salmon

Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States, as far south as Monterey Bay, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast.

Chum salmon (*Oncorhynchus keta*) are semelparous, spawn primarily in freshwater and, apparently, exhibit obligatory anadromy (there are no recorded landlocked or naturalized freshwater populations) (Randall et al. 1987). Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Like pink salmon, chum salmon usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 km from the sea. Juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

4. Sockeye Salmon

Snake River sockeye salmon adults enter the Columbia River primarily during June and July. Arrival at Redfish Lake, which now supports the only remaining run of Snake River sockeye salmon, peaks in August and spawning occurs primarily in October (Bjornn et al. 1968). Eggs hatch in the spring

between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge in April through May and move immediately into the lake. Once there, juveniles feed on plankton for one to three years before they migrate to the ocean (Bell 1986). Migrants leave Redfish Lake during late April through May (Bjornn et al. 1968) and travel almost 900 miles to the Pacific Ocean. Smolts reaching the ocean remain inshore or within the influence of the Columbia River plume during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart 1973, Hart and Dell 1986). Snake River sockeye salmon usually spend two to three years in the Pacific Ocean and return in their fourth or fifth year of life. For detailed information on the Snake River sockeye salmon, see Waples et al. (1991).

C. Population Dynamics and Distribution

The following sections provide specific information on the distribution and population structure (size, variability, and trends of the stocks or populations) of each listed ESU. Most of this information comes from observations made in terminal, freshwater areas, which may be distinct from the action area. This focus is appropriate because the species status and distribution can only be measured at this level of detail as adults return to spawn.

1. Chinook Salmon

Snake River Spring/Summer Chinook Salmon

The present range of spawning and rearing habitat for naturally-spawned Snake River spring/summer chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon subbasins. Most Snake River spring/summer chinook salmon enter individual subbasins from May through September. Juvenile Snake River spring/summer chinook salmon emerge from spawning gravels from February through June (Perry and Bjornn 1991). Typically, after rearing in their nursery streams for about one year, smolts begin migrating seaward in April and May (Bugert et al. 1990; Cannamela 1992). After reaching the mouth of the Columbia River, spring/summer chinook salmon probably inhabit nearshore areas before beginning their northeast Pacific Ocean migration, which lasts two to three years. Because of their timing and ocean distribution, these stocks are subject to very little ocean harvest. For detailed information on the life history and stock status of Snake River spring/summer chinook salmon, see Matthews and Waples (1991), NMFS (1991a), and 56 FR 29542 (June 27, 1991).

Bevan et al. (1994) estimated the number of wild adult Snake River spring/summer chinook salmon in the late 1800s to be more than 1.5 million fish annually. By the 1950s, the population had declined to an estimated 125,000 adults. Escapement estimates indicate that the population continued to decline through the 1970s. Returns were variable through the 1980s, but declined further in recent years. Record low returns were observed in 1994 and 1995. Dam counts were modestly higher from 1996 through 1998, but declined in 1999. For management purposes the spring and summer chinook in the Columbia Basin, including those returning to the Snake River, have been managed as separate stocks.

Historic databases therefore provide separate estimates for the spring and summer chinook components. **Table 3** reports the estimated annual return of adult, natural-origin SR spring and summer chinook salmon returning to Lower Granite Dam since 1979. A preliminary estimated of the Recovery Escapement goal for SR spring/summer chinook of 31,440 (counted at Ice Harbor Dam) was suggested in NMFS' Proposed Recovery Plan (NMFS 1995).

Table 3. Estimates of natural-origin Snake River spring/summer chinook salmon counted at Lower Granite Dam in recent years (Speaks 2000).

Year	Spring Chinook	Summer Chinook	Total
1979	2,573	2,712	5,285
1980	3,478	2,688	6,166
1981	7,941	3,326	11,267
1982	7,117	3,529	10,646
1983	6,181	3,233	9,414
1984	3,199	4,200	7,399
1985	5,245	3,196	8,441
1986	6,895	3,934	10,829
1987	7,883	2,414	10,297
1988	8,581	2,263	10,844
1989	3,029	2,350	5,379
1990	3,216	3,378	6,594
1991	2,206	2,814	5,020
1992	11,285	1,148	12,433
1993	6,008	3,959	9,967
1994	1,416	305	1,721
1995	745	371	1,116
1996	1,358	2,129	3,487
1997	1,434	6,458	7,892
1998	5,055	3,371	8,426
1999	1,433	1,843	3,276
Recovery Esc Level			31,440

The Snake River spring/summer chinook salmon ESU consists of 39 local spawning populations (subpopulations) spread over a large geographic area (Lichatowich et al. 1993). The number of fish returning to Lower Granite Dam is therefore divided among these subpopulations. The relationships between these subpopulations, and particularly the degree to which individuals may intermix is unknown. It is unlikely that all 39 are independent populations per the definition in McElhany et al. (2000), which requires that each be isolated such that the exchange of individuals between populations does not substantially affect population dynamics or extinction risk over a 100-year time frame. Nonetheless, monitoring the status of subpopulations provides more detailed information on the status of the species than would an aggregate measure of abundance.

Seven of these subpopulations have been used as index stocks for the purpose of analyzing extinction risk and alternative actions that may be taken to meet survival and recovery requirements. The Snake River Salmon Recovery Team selected these subpopulations primarily because of the availability of relatively long time series of abundance data. The BRWG developed recovery and threshold abundance levels for the index stocks, which serve as reference points for comparisons with observed escapements (**Table 4**). The threshold abundances represent levels at which uncertainties (and thus the likelihood of error) about processes or population enumeration are likely to be biologically significant, and at which qualitative changes in processes are likely to occur. They were specifically not developed as indicators of pseudo-extinction or as absolute indicators of “critical” thresholds. In any case, escapement estimates for the index stocks have generally been well below threshold levels in recent years (**Table 4**).

Table 4. Number of adult spawners, recovery levels, and BRWG threshold abundance levels (see text) for Snake River spring/summer chinook salmon index stocks. Spring chinook index stocks: Bear Valley, Marsh, Sulphur and Minam. Summer-run index stocks: Poverty Flats and Johnson. Run-timing for the Imnaha is intermediate. Estimates for 2000 (shown in italics) are based on the preseason forecast.

Brood year	Bear Valley	Marsh	Sulphur	Minam	Imnaha	Poverty Flats	Johnson
1979	215	83	90	40	238	76	66
1980	42	16	12	43	183	163	55
1981	151	115	43	50	453	187	102
1982	83	71	17	104	590	192	93
1983	171	60	49	103	435	337	152
1984	137	100	0	101	557	220	36
1985	295	196	62	625	699	341	178
1986	224	171	385	357	479	233	129
1987	456	268	67	569	448	554	175
1988	1109	395	607	493	606	844	332
1989	91	80	43	197	203	261	103
1990	185	101	170	331	173	572	141
1991	181	72	213	189	251	538	151
1992	173	114	21	102	363	578	180
1993	709	216	263	267	1178	866	357
1994	33	9	0	22	115	209	50
1995	16	0	4	45	97	81	20
1996	56	18	23	233	219	135	49
1997	225	110	43	140	474	363	236
1998	372	164	140	122	159	396	119
1999	72	0	0	96	282	153	49
<i>2000</i>	<i>58</i>	<i>19</i>	<i>24</i>	<i>240</i>	<i>na</i>	<i>280</i>	<i>102</i>
Recovery Level	900	450	300	450	850	850	300
BRWG Threshold	300	150	150	150	300	300	150

As of June 1, 2000, the preliminary final aggregate count for upriver spring chinook salmon at Bonneville Dam was 178,000, substantially higher than the 2000 forecast of 134,000¹. This is the second highest return in 30 years (after the 1972 return of 179,300 adults). Only a small portion of these are expected to be natural-origin spring chinook destined for the Snake River (5,800). However, the aggregate estimate for natural-origin SR spring chinook salmon is, nonetheless, substantially higher than the contributing brood year escapements. The comparable returns to the Columbia River mouth in 1995 and 1996 were 1,829 and 3,903, respectively. The expected returns to the index areas were estimated by multiplying the anticipated return to the river mouth by factors that accounted for anticipated harvest (approximately 9%), interdam loss (50%), prespawning mortality (10%), and the average proportion of total natural-origin spring chinook salmon expected to return to the index areas (14.3%). This rough calculation suggests that the returns to each index area would just replace the primary contributing brood year escapement (1996) (**Table 4**). These results also suggest that other areas may benefit more than the index areas in terms of brood year return rates. Recall that the index areas, on average, account for about 14% of the return of natural-origin spring chinook stocks to the Snake River. The substantial return of hatchery fish will also provide opportunities to pursue supplementation options designed to help rebuild natural-origin populations subject to constraints related to population diversity and integrity. For example, expected returns of the Tucannon River (500 listed hatchery and wild fish), Imnaha River (800 wild and 1,600 listed hatchery fish), and Sawtooth Hatchery (368 listed hatchery fish) all represent substantial increases over past years and provide opportunities for supplementation in the local basins designed to help rebuild the natural-origin stocks.

The 2000 forecast for the upriver summer chinook stocks is 33,300 which is again the second highest return in over 30 years, but with only a small portion (2,000) being natural-origin fish destined for the Snake River. The return of natural-origin fish compares to brood year escapements in 1995 and 1996 of 534 and 3,046 and is generally lower than the average returns over the last five years (3,466). The expected returns to the Poverty Flats and Johnson Creek index areas using methods similar to those described above indicates that returns will approximately double the returns observed during 1996, the primary contributing brood year (**Table 4**) and would be at least close to threshold escapement levels. Again, the substantial returns of hatchery fish can be used in selected areas to help rebuild at least some of the natural-origin stocks. Unfortunately, with the exception of the Imnaha, local brood stocks are not currently available for the spring and summer chinook index areas.

The probability of meeting survival and recovery objectives for SR spring/summer chinook under various future operation scenarios for the hydrosystem was analyzed through a process referred to as PATH (Plan for Analyzing and Testing Hypotheses). The scenarios analyzed focused on status quo management, and options that emphasized either juvenile transportation or hydro-project drawdown. PATH also included sensitivity analyses to alternative harvest rates and habitat effects. PATH estimated the probability of survival and recovery for the seven index stocks using the recovery and

¹ Source: June 1, 2000, E-mail from R. Bayley (NMFS) to Stephen H. Smith (NMFS). "Spring chinook update (end-of-season at Bonneville Dam)."

escapement threshold levels as abundance indicators. The forward simulations estimated the probability of meeting the survival thresholds after 24 and 100 years.

A 70% probability of exceeding the threshold escapement levels was used to assess survival. Recovery potential was assessed by comparing the projected abundance to the recovery abundance levels after 48 years. A 50% probability of exceeding the recovery abundance levels was used to evaluate recovery by comparing the eight-year mean projected abundance. In general the survival and recovery standards were met for operational scenarios involving drawdown, but were not met under status quo management or for the scenarios that relied on juvenile transportation (Marmorek et al. 1998). If the most conservative harvest rate schedule was assumed, transportation scenarios came very close to meeting the survival and recovery standards.

The NMFS set an interim recovery level for SR spring/summer chinook salmon (31,400 adults at Ice Harbor Dam) in its proposed recovery plan (Table 1.3-1 in NMFS 1995). For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.967 based on projected escapement trends and an assumption that future environmental conditions will be similar to those observed during the base period (i.e., 1980 through 1994; McClure et al. 2000). The CRI also estimated λ and the risk of extinction (≤ 1 fish per generation) for each of the seven spring/summer chinook salmon index populations in the Snake basin. Estimates for the subbasin populations incorporated the proportion of spawners that were hatchery fish but assumed that hatchery fish do not reproduce.² In the case of SR spring/summer chinook salmon, average subbasin population growth rates ranged from 0.891 for the Imnaha River to 0.996 for Poverty Flats (**Table 5**).³ The risk of absolute extinction within 100 years ranged from 1% for Johnson Creek to 99% for the Imnaha River.

² If this assumption is incorrect, the growth rate of the wild segment will be over-estimated.

³ The average rate of population growth and risk of extinction could not be estimated for Bear Creek spring/summer chinook salmon because there was not enough information on the proportion of wild spawners that were hatchery fish.

Appendix A

June 2000

Table 5. Results of the Dennis Extinction Analysis for individual stocks (McClure et al. 2000). The threshold for the risk of absolute extinction is one fish returning in one generation; the risk of a 90% decline in abundance is also shown. This analysis incorporated the proportion of natural spawners that were of hatchery-origin but assumed that hatchery fish did not reproduce. “N/A” indicates that no hatchery data were available¹, that the data are index counts and therefore are not appropriate for estimating population size², or that data are too sparse to perform any of these analyses³.

Species	ESU	Stream	Estimated	Lambda	Risk of Absolute Extinction			Risk of a 90% Decline in Abundance		
			Pop. Size		24-Year	48-Year	100-Year	24-Year	48-Year	100-Year
Chinook Salmon										
	Snake River Spring/Summer ESU									
		Bear Creek ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Imnaha River	1,175	0.891	0.00	0.17	0.99	0.69	0.99	1.00
		Johnson Creek	457	0.995	0.00	0.00	0.01	0.02	0.09	0.20
		Marsh Creek	291	0.942	0.01	0.18	0.64	0.31	0.59	0.85
		Minam River	582	0.901	0.03	0.39	0.90	0.54	0.84	0.98
		Poverty Flats Creek	1,055	0.996	0.00	0.00	0.02	0.06	0.14	0.25
		Sulphur Creek	207	0.972	0.13	0.32	0.56	0.30	0.42	0.53
	Snake River Fall ESU		2,199	0.940	0.00	0.00	0.32	0.25	0.65	0.94
	Upper Columbia River Spring-run ESU									
		Methow River	433	0.932	0.07	0.33	0.71	0.40	0.62	0.82
		Entiat River	173	0.890	0.00	0.68	1.00	0.71	1.00	1.00
		Wenatchee River	805	0.801	0.03	1.00	1.00	1.00	1.00	1.00
	Upper Willamette River ESU		6,859	0.988	0.00	0.01	0.07	0.17	0.29	0.40
		McKenzie River (above Leaburg)								

Appendix A

June 2000

Species	ESU	Stream	Estimated	Lambda	Risk of Absolute Extinction			Risk of a 90% Decline in Abundance		
			Pop. Size		24-Year	48-Year	100-Year	24-Year	48-Year	100-Year
Chinook Salmon (continued)										
Lower Columbia River ESU										
		Bear Creek	507	0.656	0.97	1.00	1.00	1.00	1.00	1.00
		Big Creek	5,964	0.947	0.00	0.00	0.06	0.15	0.59	0.94
		Clatskanie River	57	0.878	0.54	0.82	0.97	0.60	0.80	0.95
		Cowlitz River - 'Tule' ²	N/A	0.952	N/A	N/A	N/A	0.24	0.51	0.79
		Elochoman Creek ²	N/A	0.952	N/A	N/A	N/A	0.37	0.51	0.66
		Germany Creek ²	N/A	1.011	N/A	N/A	N/A	0.08	0.14	0.18
		Gnat Creek	211	0.950	0.18	0.42	0.69	0.37	0.51	0.66
		Grays River - 'Tule' ²	N/A	0.773	N/A	N/A	N/A	0.89	0.99	1.00
		Kalama River - Spring-run ²	N/A	0.945	N/A	N/A	N/A	0.31	0.56	0.82
		Kalama River ²	N/A	1.018	N/A	N/A	N/A	0.22	0.26	0.29
		Klaskanine River	54	0.710	0.97	1.00	1.00	0.99	1.00	1.00
		Lewis River - 'Bright' ²	N/A	0.990	N/A	N/A	N/A	0.02	0.10	0.27
		Lewis River - Spring-run ²	N/A	0.948	N/A	N/A	N/A	0.37	0.52	0.68
		Lewis, East Fork - 'Tule' ²	N/A	0.967	N/A	N/A	N/A	0.02	0.25	0.77
		Mill Creek - Fall-run	615	0.765	0.57	0.99	1.00	0.98	1.00	1.00
		Plympton Creek	5,983	1.002	0.00	0.00	0.02	0.10	0.18	0.26
		Sandy River - Late-run	4,263	0.939	0.00	0.00	0.06	0.09	0.81	1.00
		Sandy River - 'Tule' ³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Skamokawa Creek ²	N/A	0.772	N/A	N/A	N/A	1.00	1.00	1.00
		Youngs River	38	0.765	0.86	0.97	1.00	0.80	0.93	0.99

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June 2000

Species	ESU	Stream	Estimated	Lambda	Risk of Absolute Extinction			Risk of a 90% Decline in Abundance		
			Pop. Size		24-Year	48-Year	100-Year	24-Year	48-Year	100-Year
Steelhead										
	Snake River ESU									
	A-run		299,161	0.913	0.00	0.00	0.00	0.42	1.00	1.00
	B-run		100,455	0.917	0.00	0.00	0.04	0.38	0.96	1.00
	Upper Columbia River ESU		7,708	0.898	0.00	0.00	0.84	0.61	0.98	1.00
	Mid-Columbia River ESU									
	Beaver Creek - Summer-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Deschutes River - Summer-run		70,501	0.848	0.00	0.00	0.00	1.00	1.00	1.00
	Mill Creek - Summer-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Shitike Creek - Summer-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Warm Springs - NF Summer-run		1,031	0.903	0.00	0.11	0.94	0.55	0.95	1.00
	Eightmile Creek - Winter-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ramsey Creek - Winter-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fifteenmile Creek - Winter-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Touchet River - Summer-run ¹		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Umatilla River - Summer-run		9,809	0.894	0.00	0.00	0.00	0.93	1.00	1.00
	Yakima River - Summer-run		5,561	0.993	0.00	0.00	0.00	0.00	0.01	0.11
	Upper Willamette River ESU									
	Molalla River		2,644	0.912	0.00	0.05	0.74	0.47	0.87	0.99
	North Santiam River		5,653	0.874	0.00	0.11	0.98	0.79	0.99	1.00
	South Santiam River		3,730	0.979	0.00	0.00	0.00	0.02	0.14	0.46
	Calapooia River		416	0.819	0.35	0.92	1.00	0.88	0.99	1.00

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June 2000

Species	ESU	Stream	Estimated	Lambda	Risk of Absolute Extinction			Risk of a 90% Decline in Abundance		
			Pop. Size		24-Year	48-Year	100-Year	24-Year	48-Year	100-Year
Steelhead (continued)										
Lower Columbia River ESU										
		Clackamas River - Summer-run	9,065	0.897	0.00	0.00	0.96	0.73	1.00	1.00
		Clackamas River - Winter-run	3,123	0.985	0.00	0.00	0.00	0.00	0.00	0.12
		Coweeman River - Winter-run ³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Eagle Creek - Winter-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Green River - Winter-run	660	0.882	0.09	0.53	0.94	0.62	0.88	0.99
		Hood River - Summer-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Hood River - Winter-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Kalama River - Summer-run	18,843	1.114	0.00	0.00	0.00	0.00	0.00	0.00
		Kalama River - Winter-run	6,294	1.028	0.00	0.00	0.00	0.00	0.00	0.00
		Lewis River - Winter-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Panther Creek –Summer-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Sandy River - Winter-run	6,012	0.945	0.00	0.00	0.04	0.12	0.64	0.98
		Toutle River - Winter-run	3,008	0.896	0.00	0.00	0.00	1.00	1.00	1.00
		Trout Creek - Summer-run ³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Washougal River - Summer-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Washougal River - Winter-run ¹	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Wind River - Summer-run ³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snake River Sockeye Salmon ³			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Columbia River Chum Salmon										
		Grays River - WF ²	N/A	1.135	N/A	N/A	N/A	0.01	0.00	0.00
		Grays River - (mouth to head) ²	N/A	0.971	N/A	N/A	N/A	0.18	0.36	0.58
		Crazy Johnson Creek ²	N/A	1.177	N/A	N/A	N/A	0.00	0.00	0.00
		Gorely Springs ³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Hardy Creek ²	N/A	1.053	N/A	N/A	N/A	0.00	0.00	0.00

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June 2000

Species	ESU	Stream	Estimated Pop. Size	Lambda	Risk of Absolute Extinction			Risk of a 90% Decline in Abundance		
					24-Year	48-Year	100-Year	24-Year	48-Year	100-Year
		Hamilton Creek ²	N/A	0.855	N/A	N/A	N/A	0.90	1.00	1.00
		Ives Island ³	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Hamilton Springs ²	N/A	1.055	N/A	N/A	N/A	0.17	0.18	0.17

Snake River Fall Chinook Salmon

The spawning grounds between Huntington (RM 328) and Auger Falls (RM 607) were historically the most important for this species. Only limited spawning activity was reported downstream from RM 273 (Waples et al. 1991a), about one mile upstream of Oxbow Dam. Since then, irrigation and hydropower projects on the mainstem Snake River have blocked access to or inundated much of this habitat—causing the fish to seek out less-preferable spawning grounds wherever they are available. Natural fall chinook salmon spawning now occurs primarily in the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater, Grand Ronde, Salmon, and Tucannon Rivers.

Adult Snake River fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon generally spawn from October through November and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Becker 1970, Allen and Meekin 1973), and juveniles rear in backwaters and shallow water areas through mid-summer prior to smolting and migrating to the ocean—thus they exhibit an “ocean” type juvenile history. Once in the ocean, they spend one to four years (though usually, three) before beginning their spawning migration. Fall returns in the Snake River system are typically dominated by four-year-old fish. For detailed information on Snake River fall chinook salmon, see NMFS (1991b) and June 27, 1991, 56 FR 29542.

No reliable estimates of historical abundance are available, but because of their dependence on mainstem habitat for spawning, fall chinook have probably been affected to a greater extent by the development of irrigation and hydroelectric projects than any other species of salmon. It has been estimated that the mean number of adult Snake River fall chinook salmon declined from 72,000 in the 1930s and 1940s to 29,000 during the 1950s. In spite of this, the Snake River remained the most important natural production area for fall chinook in the entire Columbia River basin through the 1950s. The number of adults counted at the uppermost Snake River mainstem dams averaged 12,720 total spawners from 1964 to 1968, 3,416 spawners from 1969 to 1974, and 610 spawners from 1975 to 1980 (Waples et al. 1991a).

Counts of adult fish of natural-origin continued to decline through the 1980s reaching a low of 78 individuals in 1990 (**Table 6**). Since then, the return of natural-origin fish to Lower Granite Dam has been variable, but generally increasing reaching a recent year high of 797 in 1997. The 1998 return declined to 306. This was not anticipated and is of particular concern because it is close to the low threshold escapement level of 300 that is indicative of increased risk (BRWG 1994). It has been suggested that the low return in 1998 was due to severe flooding in 1995 that affected the primary contributing brood year. The expected return of natural-origin adults to Lower Granite Dam in 1999 given the anticipated ocean and inriver fisheries is 518.

The recovery standard identified in the 1995 Proposed Recovery Plan (NMFS 1995) for Snake River fall chinook was a population of at least 2,500 naturally produced spawners (to be calculated as an eight year geometric mean) in the lower Snake River and its tributaries. The adult counts at Lower Granite Dam cannot be compared directly to the natural spawner escapement because it is also necessary to account for adults which may fall back below the dam after counting and prespawning mortality. A preliminary estimate suggested that a Lower Granite Dam count of 4,300 would be necessary to meet the 2,500-fish escapement goal (NMFS 1995). For comparison, the geometric mean of the Lower Granite Dam counts of natural-origin fall chinook over the last eight years is 481.

A further consideration regarding the status of SR fall chinook is the existence of the Lyons Ferry Hatchery stock which is considered part of the ESU. There have been several hundred adults returning to the Lyons Ferry Hatchery in recent years (**Table 6**). More recently, supplementation efforts designed to accelerate rebuilding were initiated beginning with smolt outplants from the 1995 brood year. The existence of the Lyons Ferry program has been an important consideration in evaluating the status of the ESU since it reduces the short-term risk of extinction by providing a reserve of fish from the ESU. Without the hatchery program the risk of extinction would have to be considered high since the ESU would otherwise be comprised of a few hundred individuals from a single population, in marginal habitat, with a demonstrated record of low productivity. Although the supplementation program likely contributes future natural origin spawners, it does little to change the productivity of the system upon which a naturally spawning population must rely. Supplementation is, therefore, not a long-term substitute for recovery. (See NMFS [1999a] for further discussion of the SR fall chinook supplementation program.)

Recent analyses conducted through the PATH process considered the prospects for survival and recovery given several future management options for the hydro system and other mortality sectors (Marmorek et al. 1998, Peters et al. 1999). That analysis indicated that the prospects of survival for Snake River fall chinook were good, but that full recovery was relatively unlikely except under a very limited range of assumptions, or unless draw down was implemented for at least the four lower Snake River dams operated by the U.S. Army Corps of Engineers. Consideration of the draw down options led to a high likelihood that both survival and recovery objectives could be achieved.

Unlike many other ESUs, SR fall chinook salmon is probably represented by only a single population that spawns in the remaining accessible habitat in the mainstem and the lower reaches of accessible tributaries.⁴ For the aggregate population (i.e., the ESU as a whole), CRI estimated an average population growth rate (λ) of 0.933 (McClure et al. 2000). The value of λ was similar (0.940) when the proportion of spawners that are hatchery fish was taken into account (**Table 5**). The

⁴ The more complex population structure that is likely to have existed historically was eliminated by upstream dams that were build without fish passage facilities.

risk of absolute extinction within 100 years was 32%.

Table 6. Escapement and stock composition of fall chinook at Lower Granite (LGR) Dam¹

Year	LGR Dam Count	Marked Fish to Lyons Ferry Hatch.	LGR Dam Escapement	Stock Comp. of Escapement to LGR		
				Wild	Hatchery Origin	
					Snake R.	Non-Snake R.
1975	1,000		1,000	1,000		
1976	470		470	470		
1977	600		600	600		
1978	640		640	640		
1979	500		500	500		
1980	450		450	450		
1981	340		340	340		
1982	720		720	720		
1983	540		540	428	112	
1984	640		640	324	310	6
1985	691		691	438	241	12
1986	784		784	449	325	10
1987	951		951	253	644	54
1988	627		627	368	201	58
1989	706		706	295	206	205
1990	385	50	335	78	174	83
1991	630	40	590	318	202	70
1992	855	187	668	549	100	19
1993	1,170	218	952	742	43	167
1994	791	185	606	406	20	180
1995	1,067	430	637	350	1	286
1996	1,308	389	919	639	74	206
1997	1,451	444	1,007	797	20	190
1998	1,909	947	962	306	479	177
1999 ²	3,381	1,519	1,862	905	882	75

¹ Information taken from *Revised Tables for the Biological Assessment of Impacts of Anticipated 1996-1998 Fall Season Columbia River Mainstem and Tributary Fisheries on Snake River Salmon Species Listed Under the Endangered Species Act*, prepared by the U.S. v. Oregon Technical Advisory Committee.

² Source: Memorandum from Glen Mendel (WDFW) to Cindy LeFluer (WDFW) dated March 3, 2000. “Fall chinook run reconstruction at LGR for 1999.”

Upper Columbia River Spring Chinook Salmon

The UCR spring chinook ESU inhabits tributaries upstream from the Yakima River to Chief Joseph Dam. Upper Columbia River spring chinook have a stream-type life history. Adults return to the Wenatchee River during late March through early May, and to the Entiat and Methow rivers during late March through June. Most adults return after spending two years in the ocean, although 20% to 40% return after three years at sea. Like SR spring/summer chinook, UCR spring chinook experience very little ocean harvest. Peak spawning for all three populations occurs from August to September. Smolts typically spend one year in freshwater before migrating downstream. There are slight genetic differences between this ESU and others containing stream-type fish, but more importantly, the ESU boundary was defined using ecological differences in spawning and rearing habitat (Myers et al. 1998). The Grand Coulee Fish Maintenance Project (1939 through 1943) may have had a major influence on this ESU because fish from multiple populations were mixed into one relatively homogenous group and redistributed into streams throughout the Upper Columbia Region.

Three independent populations of spring chinook salmon are identified for the ESU including those that spawn in the Wenatchee, Entiat, and Methow basins (Ford et al. 1999). The number of natural-origin fish returning to each subbasin is shown in **Table 7**. The NMFS recently proposed Interim Recovery Abundance Levels and Cautionary Levels (i.e., interim levels still under review and are subject to change). Ford et al. (1999) characterize Cautionary Levels as abundance levels that the population fell below only about 10% of the time during a historical period when it was considered to be relatively healthy. Escapements for UCR spring chinook salmon have been substantially below the Cautionary Levels in recent years, especially 1995, indicating increasing risk to and uncertainty about the population's future status. On the other hand, preliminary returns for 1999, the primary return year for the 1995 brood, indicate that although they were low, returns were still substantially higher than the estimated cohort replacement level. Very strong 1999 jack returns suggest that survival rates for the 1996 brood will be high, as well. A total of 4,500 natural-origin UCR spring chinook are expected to return to the mouth of the Columbia River during 2000 with a corresponding expected return to each subbasin (accounting for expected harvest, inter-dam loss, and prespawning mortality) at approximately its respective Cautionary Level (**Table 7**).

Table 7. Estimates of the number of natural-origin fish returning to subbasin for each independent population of UCR spring chinook salmon and preliminary Interim Recovery Abundance and Cautionary levels.

Year	Wenatchee River	Entiat River	Methow River
1979	1,154	241	554
1980	1,752	337	443
1981	1,740	302	408
1982	1,984	343	453
1983	3,610	296	747
1984	2,550	205	890
1985	4,939	297	1,035
1986	2,908	256	778
1987	2,003	120	1,497
1988	1,832	156	1,455
1989	1,503	54	1,217
1990	1,043	223	1,194
1991	604	62	586
1992	1,206	88	1,719
1993	1,127	265	1,496
1994	308	74	331
1995	50	6	33
1996	201	28	126
1997	422	69	247
1998	218	52	125
1999 ¹	119	64	73
2000	1,295	180	811
Recovery Abundance	3,750	500	2,000
Cautionary Abundance	1,200	150	750

¹ Estimates for 1999 are preliminary; estimates for 2000 (*italics*) are based on the preseason forecast.

Six hatchery populations are included in the listed ESU; all six are considered essential for recovery. Recent artificial production programs for fishery enhancement and hydropower mitigation have been a concern because a non-native (Carson Hatchery) stock was used. However, programs have been initiated to develop locally-adapted brood stocks to supplement natural populations and facilities where straying and interactions with natural stock are known problems are phasing out use of Carson stock. Captive broodstock conservation programs are under way in Nason Creek and White River (the Wenatchee basin) and in the Twisp River (Methow basin), to prevent the extinction of those spawning populations. All spring chinook salmon passing Wells Dam in 1996 and 1998 were trapped and brought into the hatchery to begin a composite-stock broodstock supplementation program for the Methow Basin.

Ford et al. (1999) proposed recovery abundance levels of for the three spawning populations in the UCR spring chinook ESU (i.e., 3,750 spawners for the Wenatchee; 2,000 for the Methow; and 500 for the Entiat river). For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.876 (McClure et al. 2000). The CRI estimated average growth rates and the risk of extinction for each of the three spawning populations, incorporating the proportion of spawners that were hatchery fish and assuming that hatchery fish do not reproduce. λ ranged from 0.801 for the Wenatchee to 0.932 for the Methow river population (**Table 5**). The risk of absolute extinction within 100 years ranged from 71% for the Methow to 100% for the Entiat and Wenatchee river populations.

As part of the Quantitative Analytical Review (QAR) for listed species (spring chinook salmon and steelhead) in the upper Columbia basin, NMFS chaired an interagency group that applied the principles contained in the draft Viable Salmonid Populations paper (McElhaney et al. 2000) to these ESUs. The QAR process used an alternative model called the Cohort Replacement Rate (CRR) Model (Botsford and Britenacher 1998) to estimate extinction risks and recovery survival requirements for the Wenatchee, Methow, and Entiat spawning populations. The CRR model is specifically adapted to the life history structure of salmon and a variation accommodates ceilings on smolt production based on estimates habitat capacity (Cooney 2000). The CRR model used the same spawner recruit data series as the CRI model and estimated similar extinction risks when applied to the same base period (1980 through 1994 brood years). The CRR estimated extinction risks within 100 years of 98 to 99% for the Wenatchee and Entiat spring chinook salmon spawning populations, and over 50% for the Methow, assuming that the conditions that affected the 1980 through 1994 brood years continue into the future. Both modeling systems indicate that substantial improvement in average survival (over the levels experienced by the 1980 through 1994 broods) will be required to reduce long-term extinction risk to acceptable levels (e.g., less than 5%).

Upper Willamette River Chinook Salmon

Upper Willamette River chinook salmon are one of the most distinct groups in the Columbia basin --

genetically, in terms of age structure, and in terms of their marine distribution (64 FR 14322). The narrow time window available for passage above Willamette Falls (at Willamette Rkm 42) may have limited migratory access to the upper basin to spring periods of high flow (Howell et al. 1985), providing reproductive isolation and thereby defining the boundary of a distinct biogeographic region. Winter steelhead and spring-run chinook salmon were indigenous above the falls, but summer steelhead, fall chinook salmon, and coho salmon were not (Busby et al. 1996). Because the Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), any reproductive isolation provided by the falls would have been uninterrupted for a considerable time period, providing the potential for significant local adaptation relative to other Columbia basin populations.

The life-history of chinook salmon in the Upper Willamette River ESU includes traits from both ocean- and stream-type development strategies: smolts emigrate both as young-of-the-year and as age-1 fish. Mattson (1962) reported three distinct migrations of juvenile spring chinook salmon in the lower Willamette River (Lake Oswego area), including movements of a given year class during late winter through spring (age-0 migrants; 40 to 100 mm), late fall-early winter (age-1 fish; 100-130 mm), and then during the following spring (age-2 fish; 100 to 140 mm). Smolt and fry migration patterns at Leaburg Dam in the McKenzie River appear to have shifted over the years; samples collected between 1948 and 1968 indicated that fry emigrated primarily during March through June (Howell et al. 1988) but now peak during January through April (earlier than in previous years) (Corps 2000). Distribution in the ocean is consistent with an ocean-type life history (the majority are caught off the coasts of British Columbia and Southeast Alaska).

Historically, five major basins produced spring chinook salmon: the Clackamas, North and South Santiam, McKenzie, and Middle Fork Willamette rivers. However, between 1952 and 1968, dams were built on all of the major tributaries occupied by spring chinook, blocking over half the most productive spawning and rearing habitat. Water management operations have also reduced habitat quality in downstream areas due to thermal effects (relatively warm water released during autumn, leads to the early emergence of stream-type chinook fry, and cold water released during spring reduces juvenile growth rates).

Spring chinook on the Clackamas River were denied access to the upper watershed after 1917, when the fish ladder washed out at Faraday Dam, but recolonized the system after 1939, when the ladder was repaired. Based on the information available, NMFS has not been able to determine whether the recolonization of the Clackamas system was human-mediated. Regardless, NMFS included natural-origin spring chinook salmon from the Clackamas subbasin as part of the listed ESU and considers this spawning population a potentially important genetic resource for recovery.

Information provided by ODFW (1998) indicates that, at present, the only significant natural production of spring-run chinook salmon above Willamette Falls occurs in the McKenzie River basin. Nicholas (1995) also suggested that a self-sustaining population exists in the North Santiam River basin

(BRT 1998) but ODFW contends that the thermal profile of water released from Detroit Dam significantly reduces the survival of any progeny from naturally-spawning fish 64 FR 14308. The McKenzie River may now account for 50% of the production potential in the Willamette River basin, with 80% of that above Leaburg Dam. The number of natural-origin fish counted at Leaburg Dam increased from 786 in 1994 to 1,364 in 1998 (**Table 8**).

The Clackamas River currently accounts for about 20% of the production potential in the Willamette River basin, originating from one hatchery plus natural production areas that are primarily located above the North Fork Dam. The interim escapement goal for the area above North Fork Dam is 2,900 fish (ODFW 1998a). However, the system is so heavily influenced by hatchery production that it is difficult to distinguish spawners of natural- from hatchery origin. Approximately 1,000 to 1,500 adults have been counted at the North Fork Dam in recent years.

More than 70% of the production capacity of the North Santiam system was blocked when Detroit Dam was built without passage facilities. The remaining downstream habitat is adversely affected by the temperature effects (i.e., warm water) of flow regulation. This system has also been substantially influenced by hatchery production, although the original genetic resource has been maintained as the Marion Forks Hatchery stock (ODFW 1998a). Despite these limitations, natural spawning continues in the lower river. The count of 194 redds in the area below Minto Dam (the lower-most dam) during 1998 was marginally higher than during either of the prior two years (Lindsay et al. 1998). The origin of these spawning adults has not been determined (although some coded-wire tag recoveries from Santiam River hatcheries have been recovered) nor has their reproductive success.

Mitigation hatcheries were built to offset the substantial habitat losses that resulted from dam construction. As a result, 85% to 95% of the production in the basin is now of hatchery origin. Although the hatchery programs have maintained broodlines that are relatively free of genetic influences from outside the basin, they may have homogenized within-basin stocks, reducing the population structure within the ESU. Prolonged artificial propagation of the majority of the production from this ESU may also have reduced the ability of Willamette River spring-run chinook salmon to reproduce successfully in the wild. Five of six existing hatchery stocks were included in the ESU but none were listed or considered essential for recovery.

The spring run has been counted at Willamette Falls since 1946 but jacks were not differentiated from the total count until 1952. The geometric mean of the estimated run size for the period 1946 through 1950 was 43,300 fish, compared to an estimate for the most recent 5-year period (1994 through 1998) of 25,500 (Table 22 in ODFW and WDFW 1999 and **Table 8**). Nicholas (1995) estimated only 3,900 natural spawners in 1994 for the ESU, approximately 1,300 of these naturally produced. The number of naturally-spawning fish has increased gradually in recent years, but NMFS believes that many are first-generation hatchery fish.

Table 8. Run size of spring chinook at the mouth of the Willamette River and counts at Willamette Falls and Leaburg Dam on the McKenzie River (Nicholas 1995; ODFW and WDFW 1998). The Leaburg counts show wild and hatchery counts combined since 1985 and wild counts only since 1994. Estimates for 1999 are preliminary.

Return Year	Estimated Number Entering Willamette River	Willamette Falls Count	Leaburg Dam Count	
			Combined	Wild Only
1985	57,100	34,533	825	
1986	62,500	39,155	2,061	
1987	82,900	54,832	3,455	
1988	103,900	70,451	6,753	
1989	102,000	69,180	3,976	
1990	106,300	71,273	7,115	
1991	95,200	52,516	4,359	
1992	68,000	42,004	3,816	
1993	63,900	31,966	3,617	
1994	47,200	26,102	1,526	786
1995	42,600	20,592	1,622	894
1996	34,600	21,605	1,445	1,086
1997	35,000	26,885	1,176	981
1998	45,100	34,461	1,874	1,364
1999	58,000	40,410	1,458	1,416

The NMFS has not proposed recovery levels for UWR chinook salmon but expects this to be the work of the recently convened Technical Recovery Team for the lower Columbia and upper Willamette river ESUs. For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.906 (McClure et al. 2000). The CRI also estimated λ (0.988) and the risk of absolute extinction within 100 years (7%) for the aggregate population on the McKenzie River above Leaburg, incorporating the proportion of spawners in the population that were hatchery fish but assuming that hatchery fish do not reproduce (**Table 5**).

Lower Columbia River Chinook Salmon

The LCR chinook salmon ESU includes spring stocks as well as fall tule and bright components. Spring-run chinook salmon on the lower Columbia River, like those from coastal stocks, enter freshwater in March and April well in advance of spawning in August and September. Historically, the spring migration was synchronized with periods of high rainfall or snowmelt to provide access to upper reaches of most tributaries, where spring stocks would hold until spawning (Fulton 1968, Olsen et al. 1992, WDF et al. 1993).

Fall chinook predominate lower Columbia River salmon runs. Fall chinook return to the river in mid-August and spawn within a few weeks (WDF et al. 1993, Kostow 1995). The majority of fall-run chinook salmon emigrate to the marine environment as subyearlings (Reimers and Loeffel 1967, Howell et al. 1985, WDF et al. 1993). Returning adults that emigrated as yearling smolts may have originated from the extensive hatchery programs within the ESU. It is also possible that modifications in the river environment have altered the duration of freshwater residence. Adult fall-run fish return to tributaries in the lower Columbia River at 3- and 4-years of age compared to 4- to 5-years for spring-run fish. This difference may be related to the predominance of yearling smolts among spring-run stocks. Marine coded-wire-tag recoveries for lower Columbia River stocks tend to occur off the British Columbia and Washington coasts, although a small proportion of the tags are recovered in Alaskan waters.

There are no reliable estimates of historical abundance for this ESU, but it is generally agreed that natural production has been greatly reduced over the last century. Recent abundance estimates include a 5-year (1991 through 1995) geometric mean natural spawning escapement of 29,000 natural spawners and 37,000 hatchery spawners. However, according to the accounting of PFMC (1996), approximately 68% of the natural spawners are first-generation hatchery strays.

Hatchery programs to enhance chinook salmon fisheries in the lower Columbia River began in the 1870s, expanded rapidly, and have continued throughout this century. Although the majority of hatchery stocks have come from within this ESU, over 200 million fish from outside the ESU have been released since 1930. A particular concern noted at the time of listing related to the straying by Rogue River fall-run chinook salmon, which are released into the lower Columbia River to augment harvest. The release strategy has since been modified to minimize straying, but it is too early to assess the effect

of the change. Available evidence indicates a pervasive influence of hatchery fish on most natural populations of LCR chinook salmon, including both spring- and fall-run populations (Howell et al. 1985, Marshall et al. 1995). In addition, the exchange of eggs between hatcheries in this ESU has led to the extensive genetic homogenization of hatchery stocks (Utter et al. 1989).

The remaining spring chinook stocks in the LCR chinook salmon ESU are found in the Sandy River, Oregon, and the Lewis, Cowlitz, and Kalama rivers, Washington. Spring chinook in the Clackamas River are considered part of the UWR chinook salmon ESU. Despite substantial influence of fish from hatcheries in the Upper Willamette River ESU in past years, naturally spawning spring chinook salmon in the Sandy River are included in the LCR chinook salmon ESU because they probably contain the remainder of the original genetic legacy for that system. Recent escapements above Marmot Dam on the Sandy River average 2,800 and have been increasing (ODFW 1998b). Hatchery-origin spring chinook are no longer released above Marmot Dam; the proportion of first generation hatchery fish in the escapement is relatively low, on the order of 10% to 20% in recent years. In 1999, the escapement dropped to 1,828 fish, in part because only unmarked “naturally produced” fish were passed over Marmot Dam (Schroeder et al. 1999).

On the Washington side, spring chinook were native to the Cowlitz and Lewis rivers and there is anecdotal evidence that a distinct spring run existed in the Kalama River subbasin (WDF 1951). The Lewis River spring run was severely affected by dam construction. During the period between the construction of Merwin Dam in 1932 and Yale Dam in the early 1950s, WDF attempted to maintain the run by collecting adults at Ariel/Merwin for hatchery propagation or (in years when returns were in excess of hatchery needs) release to the spawning grounds (WDF 1951). As native runs dwindled, Cowlitz spring-run chinook salmon were reintroduced in an effort to maintain them. In the Kalama River, escapements of less than 100 fish were present until the early 1960s when spring-run hatchery production was initiated with a number of stocks from outside the basin. Recent (1994 through 1998) average estimates for naturally spawning spring chinook are 235, 224, and 372 fish in the Cowlitz, Kalama, and Lewis rivers, respectively. Some (perhaps a large) proportion of the natural spawners in each system is believed to be hatchery strays (ODFW 1998b). Although, the Lewis and Kalama hatchery stocks have been mixed with out-of-basin stocks, they are included in the ESU. The Cowlitz River hatchery stock is largely free of introductions. Although it is considered essential for recovery it is not listed because the state of Washington’s hatchery and harvest practices were considered sufficiently protective of this stock that their future existence and value for recovery are not at risk (64 FR 14321). Numbers of spring chinook returning to the Cowlitz, Kalama, and Lewis rivers have declined in recent years, but still number several hundred to a few thousand in each system (**Table 9**).

There are apparently three self-sustaining natural populations of tule chinook in the lower Columbia River (Coweeman, East Fork Lewis, and Clackamas) that are not substantially influenced by hatchery strays. Returns to the East Fork and Coweeman have been stable and near interim escapement goals in recent years. Recent 5- and 10-year average escapements to the East Fork Lewis River have been

about 300 compared to an interim escapement goal of 300. Recent 5- and 10-year average escapements to the Coweeman River are 900 and 700, respectively compared to an interim natural escapement goal of 1,000 (pers. comm., from G. Norman, WDFW to P. Dygert NMFS, February 22, 1999). Natural escapement on the Clackamas has averaged about 350 in recent years. There have been no releases of hatchery fall chinook in the Clackamas since 1981 and there are apparently few hatchery strays. The population is considered depressed, but stable and self-sustaining (ODFW 1998b). There is some natural spawning of tule fall chinook in the Wind and Little White Salmon Rivers, tributaries above Bonneville Dam (the only component of the ESU that is affected by tribal fisheries). Although there may be some natural production in these systems, the spawning results primarily from hatchery-origin strays.

Escapement of LCR bright fall chinook salmon to the North Fork Lewis River exceeded its escapement goal of 5,700 by a substantial margin every year from the 1970s until 1978. However, runs have been declining and, probably combined with the effect of the 1996 and 1997 floods on habitat, the 1999 return was low (about 3,300). A return of 2,700 is forecast for 2000 (PFMC 2000).

There are two smaller populations of LCR bright fall chinook salmon in the Sandy and East Fork Lewis rivers. Run sizes in the Sandy River have averaged about 1,000 and have been stable for the last 10 to 12 years. The fall chinook hatchery program in the Sandy River was discontinued in 1977, with the intention of reducing the number of hatchery strays in the system. There is also a late spawning component in the East Fork Lewis River that is comparable in timing to the other 'bright' stocks. The escapement of these fish is less well documented, but it appears to be stable and largely unaffected by hatchery fish (ODFW 1998b).

All basins in the region are affected to varying degrees by habitat degradation. Major habitat problems are related primarily to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in flood plains and low-gradient tributaries. Substantial chinook salmon spawning habitat has been blocked (or passage substantially impaired) in the Cowlitz (Mayfield Dam 1963, RKm 84), Lewis (Merwin Dam 1931, RKm 31), Clackamas (North Fork Dam 1958, RKm 50), Hood (Powerdale Dam 1929, RKm 7), and Sandy (Marmot Dam 1912, RKm 48; Bull Run River dams in the early 1900s) rivers (WDF et al. 1993, Kostow 1995).

The NMFS has not proposed recovery levels for LCR chinook salmon but expects this to be the work of the recently convened Technical Recovery Team for the lower Columbia and upper Willamette river ESUs. For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.943 (McClure et al. 2000). The CRI also estimated average population growth rates and the risk of extinction for 19 subbasin populations, incorporating the proportion of spawners in the population that were hatchery fish but assuming that hatchery fish do not reproduce. λ ranged from 0.656 for Bear Creek to 1.018 for the Kalama River (**Table 5**). The risk of absolute extinction within 100 years ranged from 2% for Plympton Creek to 100% for Bear and Mill creeks and for the Klaskanine and

Youngs rivers. Extinction risk could not be estimated for most Washington subbasins because data were peak counts and therefore not appropriate for use with the Dennis model.

Table 9. Estimated Lower Columbia River adult spring chinook salmon returns to tributaries, 1992 through 1999 (Pettit 1998, ODFW and WDFW 1999).

Year	Sandy River	Cowlitz River	Lewis River	Kalama River	Total Returns (Excluding Willamette)
1992	8,600	10,400	5,600	2,400	27,200
1993	6,400	9,500	6,600	3,000	25,500
1994	3,500	3,100	3,000	1,300	10,900
1995	2,500	2,200	3,700	700	9,100
1996	4,100	1,800	1,700	600	8,200
1997	5,200	1,900	2,200	600	9,900
1998	4,300	1,100	1,600	400	7,400
1999		1,600	1,900	600	

2. Steelhead

Snake River Steelhead

The longest consistent indicator of steelhead abundance in the Snake River basin is based on counts of natural-origin steelhead at the uppermost dam on the lower Snake River. The abundance of natural-origin summer steelhead at the uppermost dam on the Snake River has declined from a 4-year average of 58,300 in 1964 to an average of 8,300 ending in 1998. In general, steelhead abundance declined sharply in the early 1970s, rebuilt modestly from the mid-1970s through the 1980s, and again declined during the 1990s (**Figure 1**).

These broad scale trends in the abundance of steelhead were reviewed through the PATH process. The PATH report concluded that the initial, substantial decline coincided with the declining trend in downstream passage survival. However, the more recent decline in abundance, observed over the last decade or more, does not coincide with declining passage survival but can be at least partially be accounted for by a shift in climatic regimes that has affected ocean survival (Marmorek 1998).

The abundance of A-run versus B-run components of Snake River basin steelhead can be distinguished in data collected since 1985. Both components have declined through the 1990s, but the decline of B-run steelhead has been more significant. The 4-year average counts at Lower Granite Dam declined from 18,700 to 7,400 beginning in 1985 for A-run steelhead and from 5,100 to 900 for B-run steelhead. Counts over the last five or six years have been stable for A-run steelhead and without significant trend (**Figure 2**). Counts for B-run steelhead have been low and highly variable, but also without apparent trend (**Figure 3**).

Comparison of recent dam counts with escapement objectives provides perspective regarding the status of the ESU. The management objective for Snake River steelhead stated in the Columbia River Fisheries Management Plan was to return 30,000 natural/wild steelhead to Lower Granite Dam. The All Species Review (TAC 1997) further clarified that this objective was subdivided into 20,000 A-run and 10,000 B-run steelhead. Idaho has reevaluated these escapement objectives using estimates of juvenile production capacity. This alternative methodology lead to revised estimates of 22,000 for A-run and 31,400 for B-run steelhead (pers. comm., S. Keifer, IDFG. with P. Dygert, NMFS).

The State of Idaho has conducted redd count surveys in all of the major subbasins since 1990. Although the surveys are not intended to quantify adult escapement, they can be used as indicators of relative trends. The sum of redd counts in natural-origin B-run production subbasins declined from 467 in 1990 to 59 in 1998 (**Figure 4**). The declines are evident in all four of the primary B-run production areas. Index counts in the natural-origin A-run production areas have not been conducted with enough consistency to permit similar characterization.

Figure 1. Adult returns of wild summer steelhead to the uppermost dam on the Snake River.

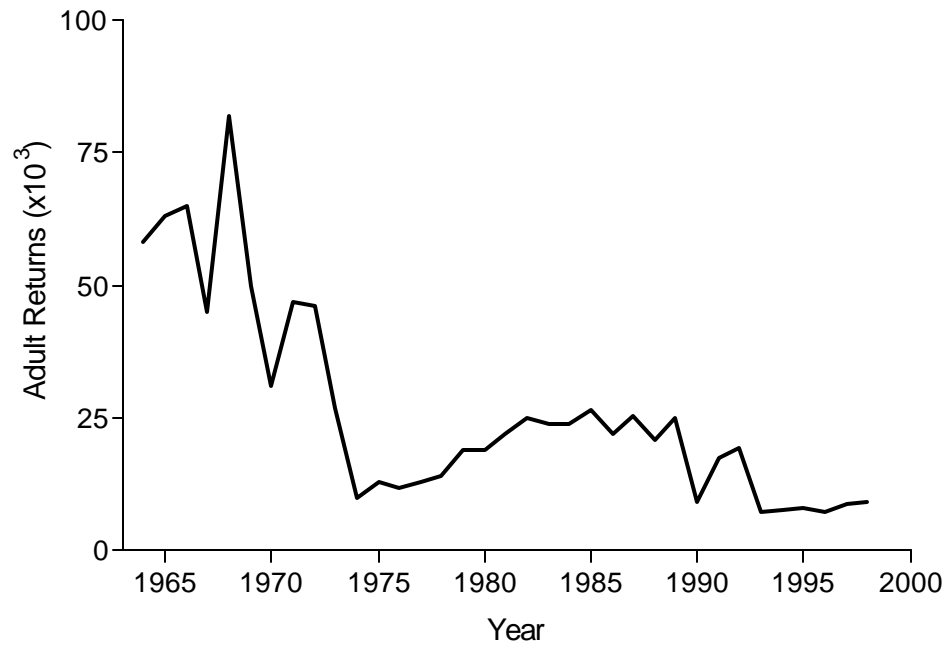


Figure 2. Escapement of A-run Snake River steelhead to the uppermost dam. Source: Data for 1980 through 1984 from Figures 1 and 2 of Section 8 in TAC (1997). Data for 1985 through 1998 from Table 2 of Section 8 (TAC 1997) and pers. Comm. G. Mauser, IDFG.

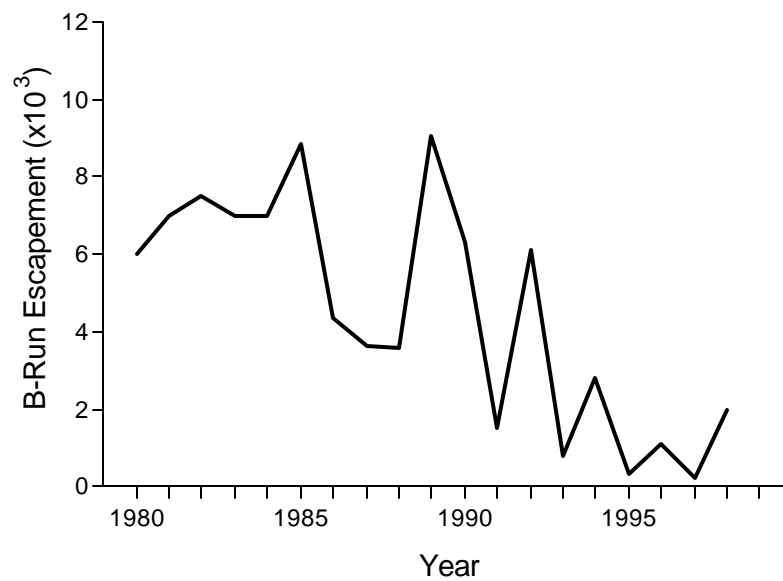


Figure 3. Escapement of B-run Snake River steelhead to the uppermost dam. Source: Data for 1980 through 1984 from Figures 1 and 2 of Section 8 in TAC (1997). Data for 1985 through 1998 from Table 2 of Section 8 (TAC 1997) and pers. Comm. G. Mauser, IDFG.

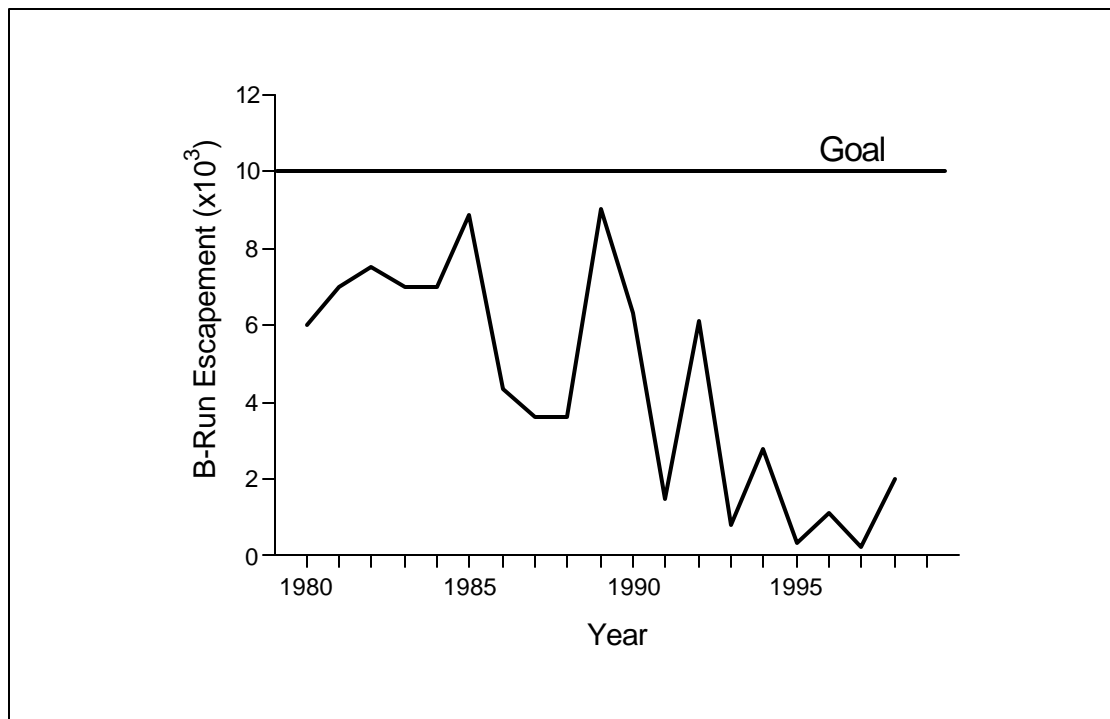
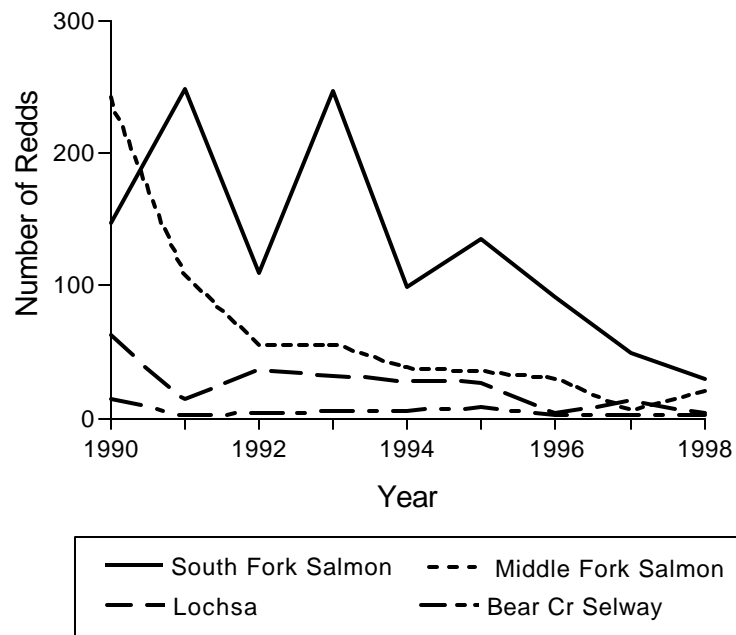
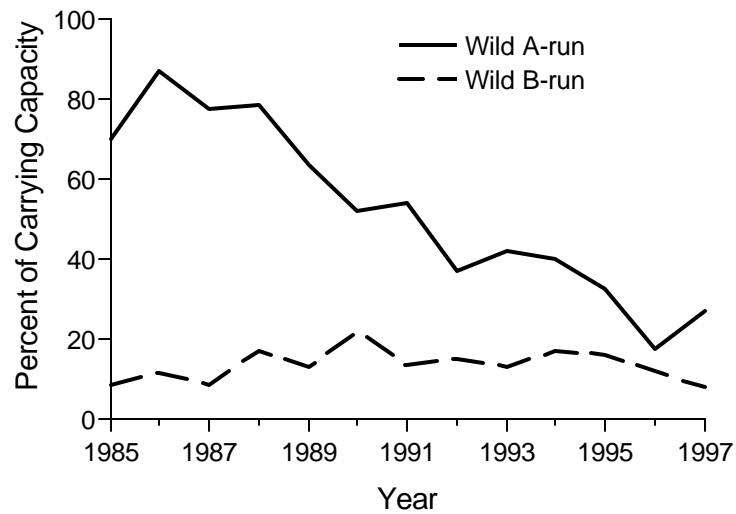


Figure 4. Redd counts for wild Snake River (B-run) steelhead in the South Fork and Middle Fork Salmon, Lochsa, and Bear Creek-Selway index areas. Data for the Lochsa exclude Fish Creek and Crooked Fork. Sources: memo from T. Holubetz (IDFG), “1997 Steelhead Redd Counts”, dated May 16, 1997, and IDFG, unpubl. data).



Idaho has also conducted surveys for juvenile abundance in index areas throughout the Snake River basin since 1985. Parr densities of A-run steelhead have declined from an average of about 75% of carrying capacity in 1985 to an average of about 35% in recent years through 1995 (**Figure 5**). Further declines were observed in 1996 and 1997. Parr densities of B-run steelhead have been low, but relatively stable since 1985, averaging 10% to 15% of carrying capacity through 1995. Parr densities in B-run tributaries declined further in 1996 and 1997 to 11% and 8%, respectively.

Figure 5. Percent of estimated carrying capacity for juvenile (age-1+ and -2+) wild A- and B-run steelhead in Idaho streams. Source: data for 1985 through 1996 from Hall-Griswold and Petrosky (1998); data for 1997 from IDFG (unpublished).



It is apparent from the available data that B-run steelhead are much more depressed than the A-run component. In evaluating the status of the Snake Basin steelhead ESU it is pertinent to consider whether B-run steelhead represent a "significant portion" of the ESU. This is particularly relevant because the tribes have proposed to manage the Snake River Basin steelhead ESU as a whole without distinguishing between components and further that it is inconsistent with NMFS authority to manage for components of an ESU.

It is first relevant to put the Snake River basin into context. The Snake River historically supported over 55% of total natural-origin production of steelhead in the Columbia basin and now has approximately 63% of the basin's natural production potential (Mealy 1997). B-run steelhead occupy four major subbasins including two on the Clearwater River (Lochsa and Selway) and two on the Salmon River (Middle Fork and South Fork Salmon), areas that for the most part are not occupied by A-run steelhead. Some natural B-run steelhead are also produced in parts of the mainstem Clearwater and its major tributaries. There are alternative escapement objectives for B-run steelhead of 10,000 (CRFMP) and 31,400 (Idaho). B-run steelhead therefore represent at least 1/3 and as much as 3/5 of the production capacity of the ESU.

B-run steelhead are distinguished from the A-run component by their unique life history characteristics. B-run steelhead were traditionally distinguished as larger and older, later-timed fish that return primarily to the South Fork Salmon, Middle Fork Salmon, Selway, and Lochsa rivers. The recent review by TAC concluded that different populations of steelhead do have different size structures, with populations dominated by larger fish (i.e., >77.5 cm) occurring in the traditionally defined B-run basins (TAC 1999). Larger fish occur in other populations throughout the basin, but at much lower rates (evidence suggests that fish returning to the Middle Fork Salmon and Little Salmon are intermediate in that they have a more equal distribution of large and small fish).

B-run steelhead are also generally older. A-run steelhead are predominately age-1-ocean fish whereas most B-run steelhead generally spend two or more years in the ocean prior to spawning. The differences in ocean age are primarily responsible for the differences in the size of A- and B-run steelhead. However, B-run steelhead are also thought to be larger at age than A-run fish. This may be due, at least in part, to the fact that B-run steelhead leave the ocean later in the year than A-run steelhead and thus have an extra month or more of ocean residence at a time when growth rates are thought to be greatest.

Historically, a distinctly bimodal pattern of freshwater entry could be used to distinguish A-run and B-run fish. A-run steelhead were presumed to cross Bonneville Dam from June to late August while B-run steelhead enter from late August to October. TAC reviewed the available information on timing and confirmed that the majority of large fish do still have a later timing at Bonneville; 70% of the larger fish crossed the dam after August 26, the traditional cutoff date for separating A- and B-run fish (TAC 1999). However, the timing of the early part of the A-run has shifted somewhat later, thereby reducing

the timing separation that was so apparent in the 1960s and 1970s. The timing of the larger, natural-origin B-run fish has not changed.

As pointed out above, the geographic distribution of B-run steelhead is restricted to particular watersheds within the Snake River basin (areas of the mainstem Clearwater, Selway, and Lochsa rivers and the South and Middle Forks of the Salmon River). No recent genetic data are available for steelhead populations in South and Middle Forks of the Salmon River. The Dworshak NFH stock and natural populations in the Selway and Lochsa Rivers are thus far the most genetically distinct populations of steelhead in the Snake River basin (Waples et al. 1993). In addition, the Selway and Lochsa river populations from the Middle Fork Clearwater appear to be very similar to each other genetically, and naturally produced rainbow trout from the North Fork Clearwater River (above Dworshak Reservoir) clearly show an ancestral genetic similarity to Dworshak NFH steelhead. The existing genetic data, the restricted geographic distribution of B-run steelhead in the Snake (Columbia) River basin, and the unique life history attributes of these fish (i.e. larger, older adults with a later distribution of run timing compared to A-run steelhead in other portions of the Columbia River basin) clearly support the conservation of B-run steelhead as a biologically significant component of the Snake River ESU.

Another approach to assessing the status of an ESU being developed by NMFS is to consider the status of its component populations. For this purpose a population is defined as a group of fish of the same species spawning in a particular lake or stream (or portion thereof) at a particular season, which to a substantial degree do not interbreed with fish from any other group spawning in a different place or in the same place at a different season. Because populations as defined here are relatively isolated, it is biologically meaningful to evaluate the risk of extinction of one population independently from any other. Some ESUs may be comprised of only one population whereas others will be constituted by many. The background and guidelines related to the assessment of the status of populations is described in a recent draft report discussing the concept of Viable Salmonid Populations (McElhany et al. 2000).

The task of identifying populations within an ESU will require making judgements based on the available information. Information regarding the geography, ecology, and genetics of the ESU are relevant to this determination. Although NMFS has not compiled and formally reviewed all the available information for this purpose, it is reasonable to conclude that, at a minimum, each of the major subbasins in the ESU represent a population within the context of this discussion. A-run populations would therefore include at least the tributaries to the lower Clearwater, the upper Salmon River and its tributaries, the lower Salmon River and its tributaries, the Grand Ronde, Imnaha, and possibly the Snake mainstem tributaries below Hells Canyon Dam. B-run populations would be identified in the Middle Fork and South Fork Salmon rivers and the Lochsa and Selway rivers (major tributaries of the upper Clearwater), and possibly in the mainstem Clearwater River, as well. These basins are, for the most part, large geographical areas and it is quite possible that there is additional population structure within

at least some of these basins. However, because that hypothesis has not been confirmed, NMFS assumes that there are at least five populations of A-run steelhead and five populations of B-run steelhead in the Snake River Basin ESU. Escapement objectives for A and B-run production areas in Idaho, based on estimates of smolt production capacity, are shown in **Table 10**.

Table 10. Adult steelhead escapement objectives based on estimates of 70% smolt production capacity.
(Note: comparable estimates are not available for populations in Oregon and Washington subbasins.)

A-Run Production Areas		B-Run Production Areas	
Upper Salmon	13,570	Mid Fork Salmon	9,800
Lower Salmon	6,300	South Fork Salmon	5,100
Clearwater	2,100	Lochsa	5,000
Grand Ronde	(1)	Selway	7,500
Imnaha	(1)	Clearwater	4,000
Total	21,970	Total	31,400

Hatchery populations, if genetically similar to their natural-origin counterparts, provide a hedge against extinction of the ESU or of the gene pool. The Imnaha and Oxbow hatcheries produce A-run stocks that are currently included in the Snake River Basin steelhead ESU. The Pahsimeroi and Wallowa hatchery stocks may also be appropriate and available for use in developing supplementation programs; the NMFS required in its recent biological opinion on Columbia basin hatchery operations that this program begin to transition to a local-origin broodstock to provide a source for future supplementation efforts in the lower Salmon River (NMFS 1999b). Although other stocks provide more immediate opportunities to initiate supplementation programs within some subbasins, it may also be necessary and desirable to develop additional broodstocks that can be used for supplementation in other natural production areas. Despite uncertainties related to the likelihood that supplementation programs can accelerate the recovery of naturally spawning populations, these hatchery stocks provide a safeguard against the further decline of natural-origin populations.

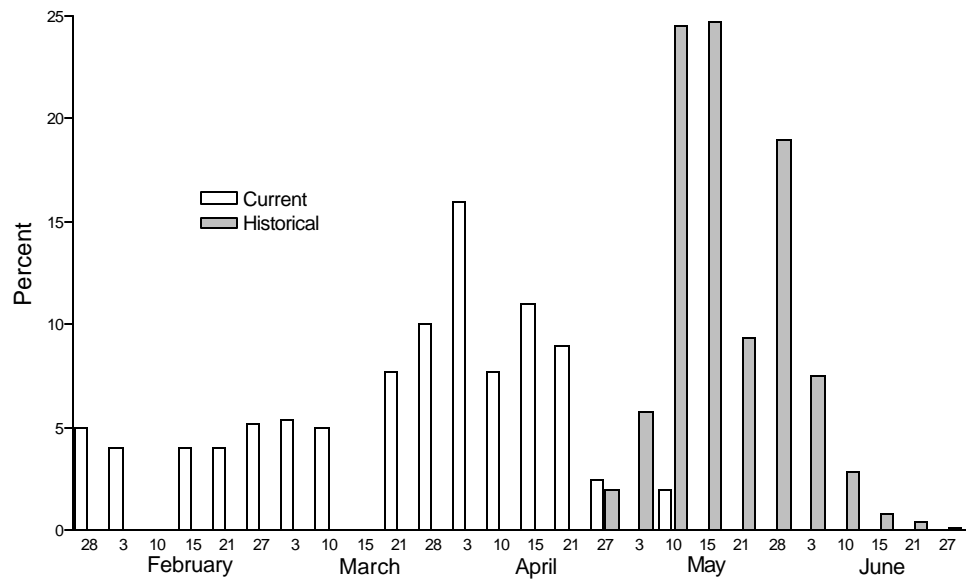
The Dworshak National Fish Hatchery (NFH) is unique in the Snake River basin in producing a B-run hatchery stock. The Dworshak stock was developed from natural-origin steelhead from within the North Fork Clearwater River, is largely free of introductions from other areas, and was therefore included in the ESU although not as part of the listed population. However, past hatchery practices and possibly changes in flow and temperature conditions related to Dworshak Dam have lead to substantial divergence in spawn timing of the hatchery stock compared to what was observed historically in the North Fork Clearwater River, and compared to natural-origin populations in other parts of the Clearwater basin. Because the spawn timing of the hatchery stock is much earlier than it was historically (**Figure 6**), the success of supplementation efforts using these stocks may be limited. In fact, past supplementation efforts in the South Fork Clearwater River using Dworshak NFH stock have been largely unsuccessful, although improvements in out-planting practices have the potential to yield different results. In addition, the unique genetic character of Dworshak Hatchery steelhead noted above will limit the degree to which the stock can be used for supplementation in other parts of the Clearwater subbasin and particularly in the Salmon River B-run basins. Supplementation efforts in those areas, if undertaken, will more likely have to rely on the future development of local broodstocks. Supplementation opportunities in many of the B-run production areas will be limited in any case because of logistical difficulties in getting to and working in these high mountain, wilderness areas. Because opportunities to accelerate the recovery of B-run steelhead through supplementation, even if successful, are expected to be limited, it is essential to maximize the escapement of natural-origin steelhead in the near term.

Finally, the conclusions and recommendations of the TAC's All Species Review are pertinent to this review of the status of Snake River steelhead. Considering information available through 1996, the 1997 All Species Review stated:

"Regardless of assessment methods for A and B steelhead, it is apparent that the primary goal of enhancing the upriver summer steelhead run is not being achieved. The status of upriver summer

steelhead, particularly natural-origin fish, has become a serious concern. Recent declines in all stocks, across all measures of abundance, are disturbing.

"There has been no progress toward rebuilding upriver runs since 1987. Throughout the Columbia River Basin, dam counts, weir counts, spawning surveys, and rearing densities indicate natural-origin steelhead abundance is declining, culminating in the proposed listing of upriver stocks in 1996. Escapements have reached critically low levels despite the relatively high productivity of natural and hatchery rearing environments. Improved flows and ocean conditions should increase smolt-adult survival rates for upriver summer steelhead. However, reduced returns in recent years are likely to produce fewer progeny and lead to continued low abundance.

Figure 6. Historical versus current spawn-timing of steelhead at Dworshak Hatchery.

"Although steelhead escapements would have increased (in some years substantially) in the absence of mainstem fisheries, data analyzed by the TAC indicate that impacts other than mainstem Columbia River fishery harvest are primarily responsible for the currently depressed status and the long term health and productivity of wild steelhead populations in the Columbia River.

"Though harvest is not the primary cause of declining summer steelhead stocks, and harvest rates have been below guidelines, harvest has further reduced escapements. Prior to 1990, the aggregate of upriver summer steelhead in the mainstem Columbia River appears at times to have led to the failure to achieve escapement goals at Lower Granite Dam. Wild Group B steelhead are presently more sensitive to harvest than other salmon stocks, including the rest of the steelhead run, due to their depressed status and because they are caught at higher rates in the Zone 6 fishery.

"Small or isolated populations are much more susceptible to stochastic events such as drought and poor ocean conditions. Harvest can further increase the susceptibility of such populations. The CRFMP recognizes that harvest management must be responsive to run size and escapement needs to protect these populations. The parties should ensure that CRFMP harvest guidelines are sufficiently protective of weak stocks and hatchery broodstock requirements."

The All Species Review included the following recommendations:

- Develop alternative harvest strategies to better achieve rebuilding and allocation objectives.
- Consider modification of steelhead harvest rate guidelines relative to stock management units and escapement needs.

The NMFS has not proposed recovery levels for SR steelhead but expects this to be the work of the Snake River Technical Recovery Team. For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.969 based on projected escapement trends and an assumption that future environmental conditions will be similar to those observed during the base period (McClure et al. 2000). The CRI also estimated average population growth rates and the risk of extinction for A-run and B-run steelhead, incorporating the proportion of spawners that were hatchery fish but assuming that hatchery fish do not reproduce. λ was 0.913 for A-run and 0.917 for B-run steelhead, respectively (**Table 5**). In both cases, the risk of absolute extinction in 100 years was very low: 0% for A-run and 4% for B-run steelhead.

The Cohort Replacement Rate (CRR) model

Upper Columbia River Steelhead

Upper Columbia River steelhead inhabit the Columbia River reach and its tributaries upstream of the Yakima River. This region includes several rivers that drain the east slopes of the Cascades Mountains

and several that originate in Canada (only U.S. populations are included in the ESU). Dry habitat conditions in this area are less conducive to steelhead survival than in many other parts of the Columbia basin (Mullan et al. 1992a). Although the life history of this ESU is similar to that of other inland steelhead, smolt ages are some of the oldest on the west coast (up to 7 years old), probably due to the ubiquitous cold water temperatures (Mullan et al. 1992b). Adults spawn later than in most downstream populations, remaining in freshwater up to a year before spawning.

Although runs during the period 1933 through 1959 may have already been affected by fisheries in the lower river, dam counts suggest a pre-fishery run size of more than 5,000 adults above Rock Island Dam. The return of Upper Columbia River natural-origin steelhead to Priest Rapids Dam declined from a 5-year average of 2,700 beginning in 1986 to a 5-year average of 900 beginning in 1994 (FPC 1998; **Table 11**). The escapement goal for natural-origin fish is 4,500. Most current natural production occurs in the Wenatchee and Methow River system, with a smaller run returning to the Entiat River. Very limited spawning also occurs in the Okanogan River basin. A majority of the fish spawning in natural production areas are of hatchery origin. Indications are that natural populations in the Wenatchee, Methow, and Entiat rivers are not self-sustaining.

This entire ESUs has been subjected to heavy hatchery influence; stocks became thoroughly mixed as a result of the Grand Coulee Maintenance Project, which began in the 1940s (Fish and Hanavan 1948, Mullan et al. 1992a). Recently, as part of the development of the Mid-Columbia Habitat Conservation Plan (HCP), it was determined that steelhead habitat within the range of the Upper Columbia ESU was overseeded, primarily due to the presence of Wells Hatchery fish in excess of those collected for broodstock. This would partially explain recent observations of low natural cohort replacement rates (0.3 for populations in the Wenatchee River and no greater than 0.25 for populations in the Entiat River; Bugert 1997). The problem of determining appropriate levels of hatchery output to prevent negative effects on natural production is a subject of analysis and review in the mid-Columbia Quantitative Analytical Report (Cooney 2000). In the meantime, given these uncertainties, efforts are underway to diversify broodstocks used for supplementation and to minimize the differences between hatchery and natural-origin fish (as well as other concerns associated with supplementation). The best use for the Wells Hatchery program in the recovery process is yet to be defined, and should be integrated with harvest activities and recovery measures to optimize the prospects for recovery of the species.

Ford et al. (1999) proposed recovery abundance levels for each of the three spawning populations identified for the UCR steelhead ESU (i.e., 2,500 spawners for the Wenatchee and Methow rivers and 500 for the Entiat River). However, the population level data were not adequate for assessing average population growth rates or the risk of extinction using the Dennis model. The CRI estimated an average growth rate (λ) for the ESU as a whole of 0.860 (McClure et al. 2000). λ was only slightly higher when the proportion of spawners that are hatchery fish was taken into account (0.898, **Table 5**). The estimated risk of absolute extinction within 100 years for the ESU as a whole was 84%.

The QAR process, applied the CRR model to the aggregate population of UCR steelhead returning to the Wenatchee and Entiat rivers and to the spawning population in the Methow (Cooney 2000). Both components are currently dominated by hatchery returns. In order to estimate extinction risk for the naturally-produced run, the model inputs included an assumption that all hatchery inputs ceased after 1999. The QAR recommended a range assumptions about the relative effectiveness of hatchery fish spawning in the wild compared to spawners of natural parentage (0.25:1 to 1:1). The higher the assumption of hatchery productivity, the higher the extinction risk of the wild segment of the population.

Table 11. Adult summer steelhead counts at Priest Rapids, Rock Island, Rocky Reach, and Wells dams (FPC 1998).

Year	Priest Rapids		Rock Island	Rocky Reach	Wells
	Count	Wild Origin	Count	Count	Count
1977	9,812		9,925	7,416	5,382
1978	4,545		3,352	2,453	1,621
1979	8,409		7,420	4,896	3,695
1980	8,524		7,016	4,295	3,443
1981	9,004		7,565	5,524	4,096
1982	11,159		10,150	6,241	8,418
1983	31,809		29,666	19,698	19,525
1984	26,076		24,803	17,228	16,627
1985	34,701		31,995	22,690	19,757
1986	22,382	2,342	22,867	15,193	13,234
1987	14,265	4,058	12,706	7,172	5,195
1988	10,208	2,670	9,358	5,678	4,415
1989	10,667	2,685	9,351	6,119	4,608
1990	7,830	1,585	6,936	5,014	3,819
1991	14,027	2,799	11,018	7,741	7,715
1992	14,208	1,618	12,398	7,457	7,120
1993	5,455	890	4,591	2,815	2,400
1994	6,707	855	5,618	2,823	2,138
1995	4,373	993	4,070	1,719	946
1996	8,376	843	7,305	5,774	4,127
1997	8,948	785	7,726	7,726	4,107
1998	5,790	919	4,810	4,265	2,482

Middle Columbia River Steelhead

Life history information for Middle Columbia River steelhead indicates that most smolt at 2 years of age and spend 1 to 2 years in salt water (i.e., 1-ocean and 2-ocean fish, respectively). After re-entering fresh water, they may remain up to a year prior to spawning (Howell et al. 1985). Within the ESU, the Klickitat River is unusual in that it produces both summer and winter steelhead, and the summer steelhead are dominated by 2-ocean steelhead (most other rivers in this region produce about equal numbers of both 1-and 2-ocean steelhead).

Escapement to the Yakima, Umatilla, and Deschutes subbasins have shown overall upward trends, although all tributary counts in the Deschutes River are downward and the Yakima River is recovering from extremely low abundance in the early 1980s. The John Day River probably represents the largest native, natural spawning stock in the ESU, and the combined spawner surveys for the John Day River have been declining at a rate of about 15% per year since 1985. However, estimates based on dam counts show an overall increase in steelhead abundance, with a relatively stable naturally-produced component. The NMFS, in proposing this ESU for listing as threatened under the ESA, cited low returns to the Yakima River, poor abundance estimates for Klickitat River and Fifteenmile Creek winter steelhead, and an overall decline for naturally-producing stocks within the ESU.

Hatchery fish are widespread and stray to spawn naturally throughout the region. Recent estimates of the proportion of natural spawners of hatchery origin range from low (Yakima, Walla Walla, and John Day rivers) to moderate (Umatilla and Deschutes rivers). Most hatchery production in this ESU is derived primarily from within-basin stocks. One recent area of concern is the increase in the number of Snake River hatchery (and possibly wild) steelhead that stray and spawn naturally within the Deschutes River Basin. Studies have been proposed to evaluate hatchery programs within the Snake River Basin that have shown high rates of straying into the Deschutes River and to make needed changes to minimize straying to rivers within the Middle Columbia River steelhead ESU.

The ESU is in the intermontane region and includes some of the driest areas of the Pacific Northwest, generally receiving less than 40 cm of rainfall annually (Jackson 1993). Vegetation is of the shrub-steppe province, reflecting the dry climate and harsh temperature extremes. Factors contributing to the decline of Middle Columbia River steelhead include agricultural practices, especially grazing and water diversions/withdrawals. In addition, hydropower development has affected the ESU through loss of habitat above tributary hydro projects and through mortalities associated with migration through the Columbia River hydrosystem.

The NMFS has not proposed recovery levels for MCR steelhead but expects this to be the work of the mid- Columbia River Technical Recovery Team. For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.893 (McClure et al. 2000). The CRI also estimated average population growth rates and the risk of extinction for four summer-run subbasin populations,

incorporating the proportion of spawners that were hatchery fish and the assumption that hatchery fish do not reproduce. Lambda ranged from 0.848 for the Deschutes River to 0.993 for the Yakima River (**Table 5**). Risk of absolute extinction within 100 years ranged from 0% for the Deschutes, Umatilla, and Yakima rivers to 94% for the North Fork Warm Springs River. The CRI could not estimate either lambda or the risk of extinction for a number of other subbasin populations because data were not available on the proportion hatchery fish.

Upper Willamette River Steelhead

The Upper Willamette River steelhead ESU occupies the Willamette River and its tributaries upstream of Willamette Falls. This is a late-migrating winter group, entering fresh water primarily during March and April (Howell et al. 1985). Only the late run is included in the ESU; the largest remaining population is in the Santiam River system. The North Santiam River hatchery stock (ODFW stock 21) is part of this ESU; listing of this hatchery stock was determined not to be warranted.

Steelhead in the Upper Willamette River basin are heavily influenced by hatchery practices and introductions of non-native stocks, and native fish into areas not originally the home of steelhead. Fishways built at Willamette Falls in 1885, modified and rebuilt several times, have facilitated the introduction of Skamania-stock summer steelhead and early-migrating winter steelhead of Big Creek stock. Non-native production of summer steelhead appears quite low, and the summer population is almost entirely maintained by artificial production (Howell et al. 1985). Some naturally-reproducing returns of Big Creek-stock winter steelhead occur in the basin (primarily early stock; **Table 12**). In recent years, releases of winter steelhead are primarily of native stock from the Santiam River system.

No estimates of abundance prior to the 1960s are available for this ESU. Recent run size can be estimated from redd counts, dam counts, and counts at Willamette Falls (late stock; **Table 12**). Recent total-basin run size estimates exhibit general declines for winter steelhead. The majority of winter steelhead populations in this basin may not be self-sustaining.

Much of the Willamette River Basin is urban or agricultural, and clearcut logging has been widespread in the Willamette River watershed. Water temperatures and streamflows reach critical levels in the basin, and channel modification and bank erosion is substantial. Artificial production practices are a major threat to this ESU. Introgression from non-local winter hatchery stocks may occur. Artificial selection of later run timing may also result from competition with substantial numbers of hatchery fish and from selective fishing pressures.

The NMFS has not proposed recovery levels for UWR steelhead but expects this to be the work of the recently convened Technical Recovery Team for the lower Columbia and upper Willamette river ESUs. For the ESU as a whole, CRI estimated an average population growth rate (lambda) of 0.879 (McClure et al. 2000). The CRI also estimated average population growth rates and the risk of

extinction for four subbasin populations, incorporating the proportion of spawners in the population that were hatchery fish but assuming that hatchery fish do not reproduce. Lambda ranged from 0.819 for the Calapooia River to 0.979 for the South Santiam River (**Table 5**) The risk of absolute extinction in 100 years ranged from 0% for the South Santiam River to 100% for the Calapooia River.

Table 12. Escapement of winter steelhead over Willamette Falls and over North Fork Dam on the Clackamas River, 1971 through 1998.

Year ¹	Willamette Falls Count			North Fork Dam
	Total	Early Stock ²	Late Stock ³	
1971	26,647	8,152	18,495	4,352
1972	23,257	6,572	16,685	2,634
1973	17,900	6,389	11,511	1,899
1974	14,824	5,733	9,091	680
1975	6,130	3,096	3,034	1,509
1976	9,398	4,204	5,194	1,488
1977	13,604	5,327	8,277	1,525
1978	16,869	8,599	8,270	2,019
1979	8,726	2,861	5,865	1,517
1980	22,356	6,258	16,097	2,065
1981	16,666	7,662	9,004	2,700
1982	13,011	6,117	6,894	1,446
1983	9,298	4,596	4,702	1,099
1984	17,384	6,664	10,720	1,238
1985	20,592	4,549	16,043	1,225
1986	21,251	8,475	12,776	1,432
1987	16,765	8,543	8,222	1,318
1988	23,378	8,371	15,007	1,773
1989	9,572	4,211	5,361	1,251
1990	11,107	1,878	9,229	1,487
1991	4,943	2,221	2,722	837
1992	5,396	1,717	3,679	2,107
1993	3,568	843	2,725	1,352
1994	5,300	1,025	4,275	1,247
1995	4,693	1,991	2,702	1,146
1996	1,801	479	1,322	325
1997	4,544	619	3,925	530
1998	3,678	757	2,921	504

¹ Represents year in which passage is completed. Passage began during the previous year. Total estimates of passage were not obtained prior to 1971 due to problems of access to the old fishway during higher flow periods.

² November 1 through February 15. These are mainly introduced Big Creek stock.

³ February 16 through May 15. These are mainly indigenous Willamette stock.

Lower Columbia River Steelhead

Busby et al. (1996) summarize the available information on the historical and recent abundances Lower Columbia River steelhead. No estimates of historical abundance (pre-1960s) specific to this ESU are available. Because of their limited distribution in upper tributaries and the urbanization surrounding the lower tributaries (e.g., the lower Willamette, Clackamas, and Sandy rivers run through Portland, Oregon, or its suburbs), summer steelhead appear to be more at risk from habitat degradation than winter steelhead. Based on angler surveys during a limited period, populations in the lower Willamette, Clackamas, and Sandy rivers appear to be stable or increasing slightly, but this type of data may not reflect trends in underlying abundances. Total annual run size is only available for the Clackamas River population (1,300 winter steelhead, 70% hatchery; 3,500 summer steelhead).

Population dynamics indicate that the Oregon component of the LCR steelhead ESU is at risk such that the capacity to survive future periods of environmental stress is unacceptably low (Chilcote 1998). The recent collapse of winter steelhead in the Clackamas River, and the status of summer steelhead in the Hood River (which together comprise 33% of the ESU) are of special concern. The Kalama River population is the only one in Washington State considered “healthy” (WDFW 1997). All of the other winter steelhead populations (i.e., those in the Cowlitz, Coweeman, North Fork and South Fork Toutle, Green, North Fork Lewis, and Washougal rivers) are considered “depressed” (WDFW 1997). The status of populations of winter steelhead in Hamilton Creek and the Wind River are unknown. The WDFW trapped fish at Shiperd Falls on the Wind River during winter 1999-2000 and will use these data to develop preliminary estimates of steelhead abundance. Among summer steelhead, populations from the Kalama River, North and East Forks of the Lewis River, and the Washougal River are considered depressed and the Wind River stock is classified as “critical” (WDFW 1997).

Recent estimates of the proportion of hatchery fish on the winter-run steelhead spawning grounds are more than 80% in the Hood and Cowlitz rivers, 45% in the Sandy, Clackamas, and Kalama rivers, and approximately 75% for summer-run steelhead in the Kalama River. Only three out of 14 populations for which data are available are estimated to have low percent hatchery fish (0% of the Washougal River summer run and of the runs in Panther and Trout creeks in the Wind River basin). The NMFS is unable to identify any natural populations of steelhead in this ESU that could be considered “healthy”, especially in light of new genetic data from WDFW that indicate some introgression between the Puget Sound Chambers Creek Hatchery stock and wild steelhead in this ESU (Phelps et al. 1997). In addition, summer steelhead, native to the Hood, Lewis, Washougal and Kalama rivers, have been introduced into the Sandy and Clackamas rivers. Naturally-spawning populations of winter steelhead appear to have been negatively affected by these introductions, probably through interbreeding and competition (Chilcote 1998).

The NMFS has not proposed recovery levels for LCR steelhead but expects this to be the work of the recently convened Technical Recovery Team for the lower Columbia and upper Willamette river ESUs.

For the ESU as a whole, CRI estimated an average population growth rate (λ) of 0.952 (McClure et al. 2000). The CRI also estimated average population growth rates and the risk of extinction for seven subbasin populations, incorporating the proportion of spawners in the population that were hatchery fish but assuming that hatchery fish do not reproduce. λ ranged from 0.882 for the Green River winter run to 1.114 for the Kalama River summer run (**Table 5**). The risk of absolute extinction in 100 years ranged from 0% for the Clackamas, Kalama, and Toutle river winter runs and the Kalama River summer-run to 96% for the Clackamas River summer run. λ and the risk of extinction could not be estimated for a number of subbasin populations either because data were entirely too sparse or data on the proportion of hatchery fish were not available.

3. Chum Salmon

Columbia River Chum Salmon

The Columbia River historically contained large runs of chum salmon that supported a substantial commercial fishery in the first half of this century. These landings represented an annual harvest of more than 500,000 chum salmon as recently as 1942. Beginning in the mid-1950s, commercial catches declined drastically and in later years rarely exceeded 2,000 per year. Annual catch, as incidental take in the late fall mainstem Columbia River fishery, has been less than 50 fish since 1994.

Fulton (1970) reported that chum salmon used 22 of 25 historical spawning areas in the lower Columbia River below The Dalles Dam. Even at the time of publication, access to suitable tributary habitat was limited by natural (falls, heavy rubble, and boulders) and manmade structures (dams and water diversions). Habitat quality was limited by siltation where watersheds had been subjected to heavy logging. Currently, spawning is limited to tributaries below Bonneville Dam, with most spawning in two areas on the Washington side of the Columbia River: Grays River, near the mouth of the Columbia River, and Hardy and Hamilton creeks, approximately 3 miles below Bonneville Dam. Some chum salmon pass Bonneville Dam, but there are no known extant spawning areas in Bonneville pool. Grays River chum salmon enter the Columbia River from mid-October to mid-November, but do not reach the Grays River until late October to early December. These fish spawn from early November to late December. Fish returning to Hamilton and Hardy Creeks begin to appear in the Columbia River earlier than Grays River fish (late September to late October) and have a more protracted spawn timing (mid-November to mid-January). All of these populations have been influenced by hatchery programs and fish transfers; the Sea Resources Hatchery on the Chinook River uses Willapa Bay chum stock and had a relatively large return (3,000 fish) in 1993. Beginning in 1999, WDFW and NMFS required that Sea Resources Hatchery either destroy their smolts or release them in Willapa Bay.

The estimated minimum run size for the Columbia River ESU has been relatively stable, albeit at a very low level, since the run collapsed during the mid-1950s (**Figure 7**). Current abundance is probably less than one percent of historical levels and the ESU has undoubtedly lost some (perhaps much) of its

original genetic diversity. Average annual natural escapement to the index spawning areas was approximately 1,300 fish for the period 1990 through 1998 (ODFW and WDFW 1999).

Index spawning areas are located in the Grays River system, near the mouth of the Columbia River, and in the Hardy Creek/Hamilton Creek/Ives Island complex below Bonneville Dam. The WDFW surveyed other (non-index) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner creeks and in the North Fork Lewis and the Washougal rivers. The State of Oregon does not conduct targeted surveys so the current extent of chum salmon spawning on the Oregon side of the river is unknown. Kostow (1995) cited reports of 23 spawning areas in Oregon tributaries but these are based on incidental observations (pers. comm., K. Kostow, Fisheries Biologist, ODFW, Portland, Oregon, August 6, 1999).

In the Grays system, chum salmon spawn in the mainstem from approximately one-half mile upstream of the West Fork downstream to the Covered Bridge, a distance of approximately four miles (WDF et al. 1992). Tributary spawning occurs in the West Fork, Crazy Johnson, and Gorely creeks. The historical influence of hatchery fish in the Grays system is small compared to other ESUs. Hatchery-cultured chum salmon from Willapa Bay (i.e., Pacific Coast chum salmon ESU) were transplanted into the Chinook River (a tributary to Baker Bay in the Columbia River estuary) during the late 1980s. Initial returns from this transplant were close to a thousand fish per year and recent returns were substantially lower (≤ 20 fish per year during 1997 and 1998). In 1998, WDFW decided that non-native chum should be removed from the system and consequently, all Willapa Bay chum salmon returning to the Sea Resources Hatchery during 1999 were destroyed. The Sea Resources and Grays River hatcheries are now used to culture CR chum salmon (collected from Gorley Creek) for reintroduction into the Chinook River. Overall, the abundance of the Grays River population has increased since the mid-1980s but appears to follow a cyclical pattern (McClure et al. 2000). The population rate of growth is positive but the cyclical trend results in a high variability around the average estimate.

The Hardy and Hamilton creeks/Ives Island complex is located approximately 2.0 miles below Bonneville Dam. Hamilton Slough once separated Hamilton Island from the Washington State shoreline. Sometime before 1978, a dike was built across the slough, separating its upstream and downstream ends (Corps 1978). The waterway that now appears to be the lower end of Hamilton Creek is actually the downstream end of the former slough; the mouth of Hamilton Creek proper adjoins the remnant slough at its northern terminus. These large-scale landscape modifications are likely to have changed the hydraulics of the Hamilton Slough/Ives Island spawning area.

Escapements to Hamilton Creek have averaged less than 100 fish in recent years. The WDFW recently completed a major habitat development project in Hamilton Springs, a spring-fed tributary to

Hamilton Creek. Chum salmon escapement to Hamilton Springs averaged 170 during the last three years (1997 through 1999; **Figure 8**). Hardy Creek is located just downstream of Hamilton Creek. Annual escapements have ranged from 22 to 1,153 spawners over the last 10 years with a generally increasing trend. Hardy Creek is now incorporated into the Pierce National Wildlife Refuge and chum salmon have benefitted from recent (and ongoing) habitat improvement programs (a vehicle bridge over Hardy Creek, cattle fencing, development of additional spawning gravels).

The current upstream extent of spawning by CR chum salmon, and thus the effect of Bonneville Dam as a barrier to migration, is unknown. Adult chum salmon are commonly thought to show little persistence in surmounting river blockages and falls (63 FR 11775). The 10-year average (1989 through 1998) count for the fish ladders at Bonneville Dam was 56 adults (**Table 13**), although this statistic is heavily skewed by a count of 195 chum salmon in 1998 (J. Loch, WDFW, unpubl. data). The unusually high count was due to (1) an increase in the effort applied to interrogating the video tapes for observations of chum salmon and (2) unusually high activity in the fish ladders at night, possibly related to unusual temperature conditions in Bonneville pool (pers. comm., J. Loch, WDFW, January 28, 2000). Without the 1998 data, the nine-year average would be only 31 adult chum. The NMFS considers these data on chum salmon passage at Bonneville Dam extremely important given the implications for spawning in Bonneville pool (i.e., and for reservoir operations that may affect spawning habitat once these areas are identified).

The NMFS has not proposed recovery levels for CR chum salmon but expects that this will be the work of the recently convened Technical Recovery Team for the lower Columbia and upper Willamette river ESUs. For the CR chum salmon ESU as a whole, CRI estimated an average population growth rate (λ) of 1.016 (McClure et al. 2000). The CRI also estimated λ and the risk of absolute extinction for six subbasin populations, incorporating the proportion of spawners in the population that were hatchery fish but assuming that hatchery fish do not reproduce. λ ranged from 0.855 for the Hamilton Creek to 1.177 for Crazy Johnson Creek (**Table 5**). The risk of absolute extinction could not be estimated for any of the subbasin populations because the data were index counts and therefore not appropriate for estimating population size.

Figure 7. Minimum run size for Columbia River chum salmon, 1938 to 1998, calculated by summing harvest, spawner surveys, and Bonneville Dam counts. Data from ODFW and WDFW (1999).

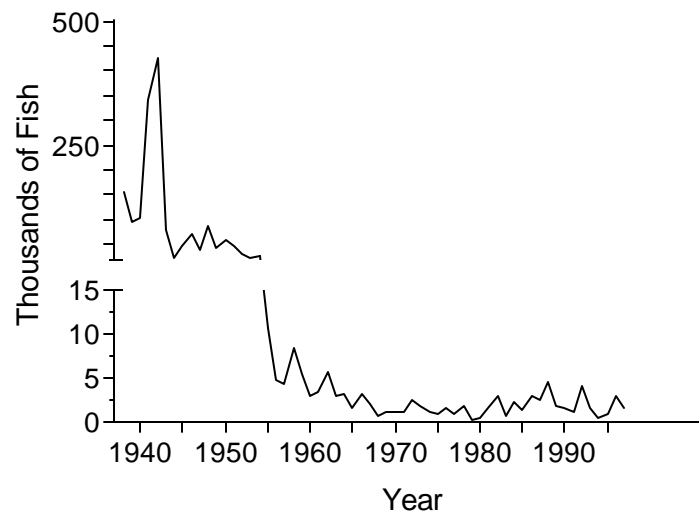


Figure 8. Peak counts of adult chum in index spawning areas, 1967 through 1999 (WDFW, unpublished data).

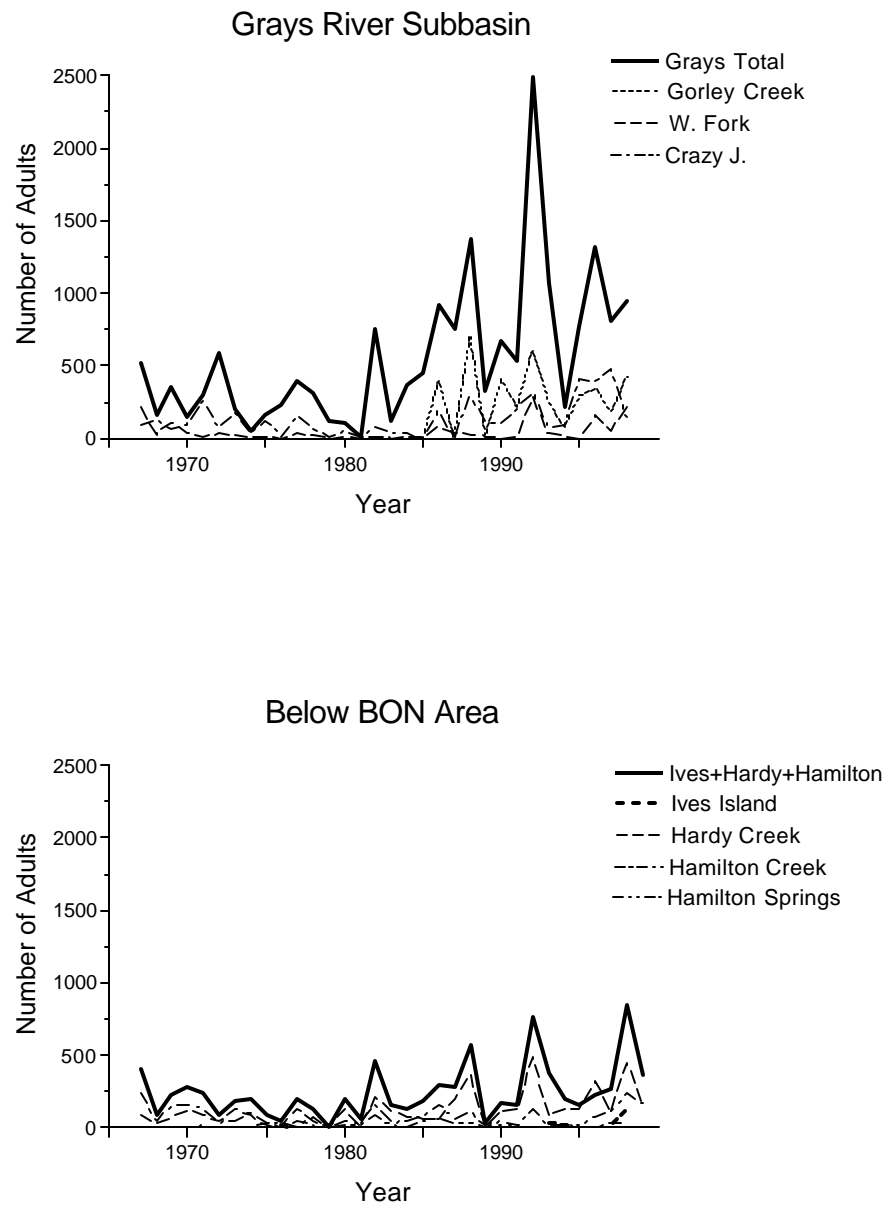


Table 13. Chum salmon counted in the Bonneville Dam adult fish ladders (1989 through 1998) (Source: J. Loch, WDFW, unpubl. data).

Year	Total Number
1989 ¹	16
1990 ¹	26
1991 ¹	5
1992 ²	39
1993 ²	51
1994 ²	26
1995 ²	30
1996 ²	33
1997 ³	50
1998 ⁴	195

The following footnotes were provided by J. Loch, WDFW:

¹ Only daytime videos available for November 1989 through 1991 (8 a.m. - 4 p.m.).

² Wild steelhead were the target species recorded from nighttime videotapes by WDFW readers. Non-target species (e.g., chum salmon) were not always recorded.

³ Wild steelhead were again the target species but some non-target species may have been recorded. Note: data for non-target species were not included in the Corps' Annual Fish Passage reports.

⁴ 1998 was the first year that the Corps contracted with the WDFW counting program to read videotapes for all salmonids. Although wild steelhead remained the target species for the video count program, observations of chums salmon, pink salmon, and chinook salmon were also tallied by the video reader. All counts were included in the Corps' annual report.

4. Sockeye Salmon

Snake River Sockeye Salmon

Historically, Snake River sockeye salmon were produced in the Stanley River subbasin of Idaho's Salmon River, in Alturas, Pettit, Redfish, and Stanley lakes, and in the South Fork Salmon River subbasin in Warm Lake. Sockeye salmon may have been present in one or two other Stanley basin lakes (Bjornn et al. 1968). Elsewhere in the Snake River basin, sockeye salmon were produced in Big Payette Lake on the North Fork Payette River and in Wallowa Lake on the Wallowa River (Evermann 1895, Toner 1960, Bjornn et al. 1968, Fulton 1970).

The largest single sockeye salmon spawning area was in the headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake. However, access to production areas in the Payette basin was eliminated by construction of Black Canyon Dam in 1924. During the 1980s, returns to headwaters of the Grand Ronde River in Oregon (Wallowa Lake) were estimated to have been at least 24,000 and 30,000 sockeye salmon (Cramer 1990), but access to the Grand Ronde was eliminated by construction of a dam on the outlet to Wallowa Lake in 1929. Access to spawning areas in the upper Snake River basin was eliminated in 1967 when fish were no longer trapped and transported around the Hells Canyon dam complex. All of these dams were constructed without fish passage facilities.

There are no reliable estimates of the number of sockeye salmon spawning in Redfish Lake at the turn of the century. However, beginning in 1910, access to all lakes in the Stanley basin was seriously reduced by the construction of Sunbeam Dam, 20 miles downstream from Redfish Lake Creek on the mainstem Salmon River. The original adult fishway, constructed of wood, was ineffective at passing fish over the dam (Kendall 1912). It was replaced with a concrete structure in 1920 but sockeye salmon access was impeded until the dam was partially removed in 1934. Even after fish passage was restored at Sunbeam Dam, sockeye salmon were unable to use spawning areas in two of the lakes in the Stanley basin. Welsh (1991) reported fish eradication projects in Pettit Lake (treated with toxaphene in 1960) and Stanley Lake (treated with Fish-Tox, a mixture of rotenone and toxaphene, in 1954). Agricultural water diversions cut off access to most of the lakes. Bjornn et al. (1968) stated that, during the 1950s and 1960s, Redfish Lake was probably the only lake in Idaho that was still used by sockeye salmon each year for spawning and rearing and, at the time of listing under the ESA, sockeye salmon were produced naturally only in Redfish Lake.

Escapement to the Snake River declined dramatically in the last several decades. Adult counts at Ice Harbor Dam declined from 3,170 in 1965 to zero in 1990 (ODFW and WDFW 1998). The Idaho Department of Fish and Game counted adults at a weir in Redfish Lake Creek during 1954 through 1966; adult counts dropped from 4,361 in 1955 to fewer than 500 after 1957 (Bjornn et al. 1968). A total of 16 wild sockeye salmon returned to Redfish Lake between 1991 and 1999 (**Table 14**). An

additional seven adults returned to the Sawtooth Hatchery during 1999; fin clips identified these adults as second generation progeny of eight wild fish that returned to Redfish Lake in 1993, were captured, and were brought into a captive broodstock program. These were the first expected returns. Progeny from the same release group (May 1998, into the Salmon River below the Sawtooth Hatchery) are expected to return through 2003.

The Snake River sockeye population currently consists of less than 10 adults. Although numbers are inadequate for a CRI-type risk of extinction analysis, clearly the risk is very high.

Table 14. Returns of Snake River sockeye salmon to Lower Granite Dam and to Redfish Lake, as determined by dam count, trapping at Redfish Lake creek weir, and spawning ground surveys. Numbers in italics (1999) represent fin-clipped adults, returning as progeny from the captive broodstock program..

Year	LGR Dam Count	Adults at Redfish Lake
1985	35	12
1986	15	29
1987	29	16
1988	23	4
1989	2	1
1990	0	0
1991	8	4
1992	1	1
1993	12	8
1994	2	1
1995	4	0
1996	0	1
1997	2	0
1998	3	1
<i>1999</i>	<i>16</i>	<i>7</i>

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HATCHERY JEOPARDY STANDARD

1. INTRODUCTION

Federal agencies are required to consult with NMFS to ensure that actions they authorize, fund, permit, or carry out are not likely to *jeopardize* the continued existence of listed species or result in the destruction or adverse modification of critical habitat. This Jeopardy Standard has been developed to guide NMFS-NWR biologists in the assessment of hatchery programs for their effects on ESA-listed anadromous fish. The Standard is to be applied when determining the conclusions of a Biological Opinion under a section 7 consultation; that an action is either likely to jeopardize, or is not likely to jeopardize.

A. DEFINITION OF JEOPARDY

Jeopardy - to engage in an action that reasonably would be expected, directly or indirectly, to reduce *appreciably* the likelihood of both the *survival* and *recovery* of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Appreciable - capable of being readily perceived or estimated; considerable.

Survival - the condition in which a species continues to exist into the future while retaining the potential or resilience to allow recovery.

Recovery - improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act. The process by which self-sustaining and self-regulating populations of a listed species are restored to become persistent members of their native biotic communities.

B. QUALITATIVE VS QUANTITATIVE ASSESSMENT

Artificial propagation is unique in that it can be one of the factors leading to the listing of a species as well as being one of the primary recovery tools (in certain circumstances) used to help rebuild severely depressed natural populations. There is substantial information available in the scientific literature that discusses likely mechanisms of interaction and possible adverse effects between hatchery produced fish

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and fish produced in their natural ecosystems. However, while these effects to naturally produced populations can be qualitatively discussed, we can not quantify or measure the effects (with few exceptions). This inability to quantify or measure impacts associated with artificial propagation is due to the complex biology of salmon, the multitude of other actions (environmental variation and man-caused) that are simultaneously affecting the natural populations, and the lack of sufficient funding (or technology) to conduct the necessary studies required to measure effects accurately. The result is a general inability to isolate most effects of artificial propagation from the multitude of other effects. As a consequence, the jeopardy analysis must be based substantially on a qualitative assessment that attempts to define the relative level of expected impacts to a listed species. This assessment must of course, be conducted conservatively in relation to the status of the listed population with the burden of proof resting clearly on the hatchery operations where species survival and recovery is most in question.

Hatchery activities are assessed biologically as they may affect the abundance, productivity, population structure, and genetic diversity of a listed species. Also, hatchery activities must be assessed relative to the effects the production of hatchery fish has on harvesting regimes; whether the intended pursuit of hatchery fish in mixed-stock fisheries has adverse effects on the naturally produced fish. Secondly, the production of hatchery fish must also be assessed for any masking effects these fish might have confounding the ability to adequately and effectively monitor the status of naturally produced fish and the health of their critical habitat in sustaining natural populations.

C. VARIATION AND EFFECTS OF OTHER H'S

In considering the real or potential effects of hatchery operations, one has to weigh the likely impact of these effects on the survival and recovery of the listed species within the context of the other factors of decline and natural variation. This is particularly important when considering the option of transitioning from the current operation to a reformed practice (see below). The rate of reform of a hatchery should, in part, be based on whether the action would be expected to appreciably reduce the risk of hazards to the listed species, potentially improving the status of the species. If the species is at or near its critical population level even small increments of improvements to the species survival and recovery are important and meaningful.

2. POPULATION PARAMETERS OF CONCERN

Hatchery program effects on the following parameters must be assessed at the individual population level (within a listed ESU). This focus on individual populations is essential because survival and recovery of an ESU depends on the viability of its component populations. It is also important to assess hatchery effects on these population parameters at the overall ESU level. However, this ESU-

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wide assessment will recognize that, in many cases, not all identified populations within an ESU need to be fully viable and recovered for the ESU to be healthy. Recovery planning processes currently in formation will be used to determine which natural populations within an ESA-listed ESU are essential for the survival and recovery of the ESU. ESU-wide assessment of cumulative population effects will be based on these determinations. In the interim, each naturally producing population within an ESU will be assumed essential for survival and recovery of the ESU unless otherwise determined during recovery planning. Prior to completion of recovery planning, greater hatchery risks for a given population could be considered as not jeopardizing the ESU if a clear case can be demonstrated that the population is not essential to survival and recovery of the ESU.

A. ABUNDANCE

Hatchery operations must not reduce populations that are at, or below, *critical population size*. Populations are at critical levels when 1) productivity variation due to demographic stochasticity becomes a substantial source of risk, 2) they cannot avoid short-term effects of inbreeding depression, or 3) compensatory processes may further reduce population productivity. Absent other, better information, critical population size for small populations should be considered to be 150 fish per generation. For larger populations, critical population size should be 300 fish per generation (PATH ?).

Hatchery operations must allow populations above their *viable population size* to remain there. Populations are viable when they 1) can survive environmental variations of magnitudes observed in the past, 2) are above levels where compensatory processes are likely to be important, and 3) should be able to maintain their genetic diversity over the long-term

Hatchery operations must not appreciably slow an increasing population from attaining its viable population size.

B. PRODUCTIVITY

For populations at or below their *critical population size*, any existing, local hatchery operation must operate to contribute to population rebuilding and/or not reduce the survival or productivity of the remaining naturally spawned fish through predation, competition, broodstock collection, or disease transfer.

Hatchery operations must allow natural populations above their *viable population size* to remain self-sustaining at levels above their viable level. The hatchery population must not become an increasing proportion of the naturally spawning population when it is at or above its viable level.

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Hatchery operations must not substantially alter the traits of the naturally spawned population that may bear upon productivity, including run timing, age structure, fish size, fecundity, morphology, and behavior.

Generally when productivity rate (as measured by S:R ratio), over time, is greater than 1, then rebuilding is occurring and additional protections from potential adverse hatchery effects may not be warranted. When S:R =1 over time, then the population is generally at a stable level which is acceptable if above the viable population size. If the population numbers are below the viable threshold, then additional measures to improve productivity must be considered. And finally if S:R < 1 over time, the population is declining and more protections are necessary, particularly if the population is nearing or below the critical threshold.

C. POPULATION SPATIAL STRUCTURE

Hatchery operations must not materially effect the spatial distribution of the associated natural population. When a naturally spawning population is at or near its viable population level, hatchery broodstock must reflect the population spatial structure into which the hatchery fish are allowed to stray, either purposefully or inadvertently, within the boundaries of a given population. Hatchery fish must not be taken from within one spatial or temporal portion of a population and then purposefully planted or allowed to stray into other portions of the population at greater-than-natural stray rates.

D. GENETIC DIVERSITY

Hatchery operations will be assessed to determine the effects on genetic diversity of the natural population. In general, those hatchery programs with broodstock derived from local populations and continually infused with naturally produced fish are believed to have less negative effect on the natural population.

Hatchery operations must not substantially alter the traits of the naturally spawned population, including run timing, age structure, size, fecundity, morphology, and behavior. Hatchery practices that would be expected to substantially alter genetic characteristics of the naturally produced populations must be avoided.

Hatchery operations must not substantially alter the rate of gene flow among populations. Between ESUs, hatchery stray rates should be managed such that less than 5% of a naturally spawning population consists of hatchery fish from another ESU.

Within an ESU, hatchery stray rates must be managed such that not more than 5% - 30% of the

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naturally spawning population consists of hatchery fish derived from within the ESU. Within this range, stray rates should be managed based on similarity of the hatchery population to the receiving natural population. For example, if the hatchery population is derived from the receiving natural population and gets regular infusion of natural fish in its broodstock, then strays rates can be at the higher end of this range (although lower rates are preferred). Conversely, if the hatchery population is derived from a population other than the receiving population, then strays should be managed to the lower end of the range. Also, if the hatchery population is derived from the receiving natural population, but has been isolated, without regular infusion of natural fish into the broodstock, then it must be managed to the lower end of the 5% - 30% range. Monitoring and evaluation, including significant marking of each hatchery release group, must be implemented and maintained.

Hatchery programs implemented for the specific purpose of enhancing the listed, naturally spawning population may by their very design, provide for a greater proportion of hatchery fish in the naturally spawning population to reduce the demographic risks of extinction. The desired proportion of hatchery fish in the spawning population must be specifically detailed in the associated HGMP for such a program. In practice this proportion (or range) may be varied to experiment with different approaches.

3. STAGES OF HATCHERY REFORM

A. HOLD THE LINE

First and foremost, all current hatchery programs affecting listed fish must be operated to ensure that actual or potential adverse effects to listed populations (previously described) are not allowed to worsen.

B. REMOVE EGREGIOUS PRACTICES

Secondly, those high risk hatchery practices that are of a magnitude and apparent in their likely adverse affect on the survival and recovery of a listed population must be immediately corrected, reformed, or ended. These are practices that have and are expected to continue to hinder the survival and recovery of the species as determined by their adverse effects on the population parameters (discussed in #2 above) . The urgency of the reform action is dependent on the scale of the effect relative to a given population and the overall ESU, and on the status of the population relative to its critical or viable status.

C. CONSISTENCY OR TRANSITION TO CONSISTENCY

Many real or potential effects of hatcheries may be portrayed, and become problematic, over longer

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time periods, but are less significant or insignificant in any given year or short-term period. Additionally, many reforms of hatcheries can not be undertaken promptly due to factors such as the lack of immediate funds or available broodstock of the appropriate lineage. In certain cases, hatchery practices that are inconsistent with survival and recovery in the long-term can be reformed transitionally without jeopardizing the long-term survival and recovery of the species. Alterations to bring a hatchery into full ESA compliance can be made over a short period, if a clear objective is stated, the time frame for transitioning is clearly described, and actions implementing the objectives do not jeopardize species survival and recovery (relative to the 4 population parameters in #2). Actions consistent with this transition will then be monitored for progress toward the “no jeopardy” state.

4. FACTORS TO CONSIDER IN ANALYSES OF HATCHERY EFFECTS

The following factors need to be considered in the context of how they affect the 4 population parameters discussed in #2.

A IMPACTS TO HABITAT

1. **CONSTRUCTION IMPACTS:** Construction activities associated with hatchery actions tend to be localized and not widespread. There is, however, opportunity to have a significant adverse effect if the activity blocks fish passage in a stream reach or results in high sediment load in the stream, particularly during spawning and egg incubation periods. Construction plans must have measures to avoid these effects and contingency plans for unanticipated repercussions.
2. **WATER WITHDRAWALS:** Hatchery water withdrawals must not de-water a stream reach such that fish migration is blocked or significantly delayed. Juvenile rearing habitat and adult spawning habitat must not be significantly reduced. Hatchery intakes may need to be screened to comply with NMFS’ screening criteria. Any long-term reduction in habitat of listed species caused by hatchery operations must be evaluated within the context of available critical habitat for the population and the ESU, and the relationship of that habitat to the survival and recovery of the species.
3. **EFFLUENT/RETURN FLOWS:** Hatchery effluents must be monitored to assure compliance with the National Pollution Discharge Elimination System Permit. Monitoring of water quality parameters should include changes in

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temperature, pH, suspended solids, ammonia, organic nitrogen, total phosphorus, and chemical oxygen demand. Additionally, the discharge of disease pathogens from the hatchery must be carefully considered. Water quality and hatchery fish health must be monitored on a regular basis.

- B. **BROODSTOCK COLLECTION:** The effects of broodstock collection must be considered for its impacts on the listed species. Issues to be evaluated include blockage, delay, or injury caused by collection methods employed (e.g. weirs, traps, seines, hook and line). Weirs must also be evaluated for any effects on spawning distribution of listed fish, whether they influence adults to spawn in lower quality habitat. Any collection methods used must be evaluated for effects to non-targeted populations. Also if broodstock is collected by volunteer returns to a hatchery ladder or trap, effects of any unintended collection of listed fish, and their disposition, must be considered.
- C. **HATCHERY MAINTENANCE:** Listed fish retained for a hatchery program must be adequately safeguarded during holding and propagation from catastrophic loss through pump failure, dewatering, flow shut-off, avian and mammal predation, poaching, and flooding. Ideally, facilities retaining listed fish must be staffed full time, and equipped with an alarm system (e.g. low flow alarm) and back-up generators to respond to power loss events. Hatchery staff must be adequately trained in fish health maintenance, sanitation, and fish cultural practices to decrease the risk of fish loss.
- D. **ECOLOGICAL EFFECTS**
 - 1. **PREDATION:** Release of hatchery fish must occur at times, locations, sizes, degree of smoltification, and/or in numbers such that predation on naturally produced fish is avoided or rendered insignificant.
 - 2. **COMPETITION:** Release of hatchery fish must occur at times, locations, sizes, degree of smoltification, and/or numbers such that competition for potentially limiting food supplies or habitat space is minimized. Consideration must be given to the specific freshwater rearing habitat, and in a cumulative context to the migration corridor, and estuarine/near ocean habitats.
 - 3. **DISEASE TRANSFER:** All hatchery programs that may potentially effect listed fish must be conducted in a manner that is consistent with Pacific Northwest Fish Health Protection Committee (PNFHPC 1989). These guidelines define rearing, sanitation, and fish health practices that minimize the incidence of

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disease outbreaks in propagated populations, thereby decreasing the risk of fish pathogen transmission to co-occurring wild populations. All hatchery-origin fish must be inspected by fish pathologists or fish health specialists to certify their disease status and health condition prior to liberation. The release of viable, healthy hatchery fish is promoted through compliance with these fish health maintenance guidelines. Release of hatchery fish with infectious disease that could be transmitted to listed species must be avoided.

4. **RESIDUALISM:** Hatchery steelhead must be released in a physiological state that minimizes their residualism. Too many residualized steelhead can be significant and sustained adverse factors of predation and competition for natural populations.
5. **ESTUARINE/OCEAN EFFECTS:** Cumulatively, hatchery releases may overwhelm estuarine and near ocean habitats when natural conditions are at low levels of productivity making these critical habitats less suitable for the growth and survival of naturally produced fish. Overall hatchery release numbers may need to be limited to avoid potential reductions in the survival, size, or fecundity of naturally produced fish. Given the large growth in juvenile hatchery fish production over the last several decades, and increasing indications of limits on salmon survival that may be posed by natural ocean productivity cycles, a cap on overall hatchery releases may be appropriate until better knowledge exists about the cumulative effects of hatchery fish releases on the survival and recovery of naturally produced populations.

E. GENETIC EFFECTS

1. **WITHIN POPULATION VARIABILITY:** Diversity within a population may be altered or lost through: intentional or artificial selection for a desired trait (e.g. adult fish size); or, through non-random or inadequate sampling of broodstock removed from the natural environment for use in a hatchery program (artificial selection). Within population diversity may also be altered or lost through unintentional or natural selection that may occur when the population is in the hatchery, causing selection for hatchery production traits that reduce the fitness of the population for the natural environment (domestication selection) (Campton 1995; Waples 1999). Domestication selection includes genetic change in a population through temporary relaxation during the culture phase of selection that otherwise would occur in the wild (Waples 1999). Inbreeding, or the selection for traits through hatchery

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practices, may limit the potential of a salmonid population to adapt to new environmental conditions, thereby reducing its capacity to buffer the total productivity of the resource against periodic or unpredictable changes (Cuenco et al. (1993) quoting Riggs 1990).

To minimize levels of inbreeding and/or selection for characteristics that are divergent from the natural population, the duration of supplementation programs should be limited, in most cases, to a maximum of three salmon generations (approximately 12 years) to minimize the likelihood for divergence between hatchery broodstocks and target natural stocks. A three generation limit for the duration of a program is intended to address the concern that repeated enhancement of the same population segment will result in a decrease in effective population size. It also limits to a few generations, the exposure of natural fish to the potentially deleterious selective effects of hatchery conditions. It is recognized, however, that if habitat is not properly functioning after the 3 generations, continuation of supplementation might be required. In addition, adults used for broodstock must be collected so that they represent, to the extent feasible, an unbiased sample of the naturally spawning donor population with respect to run timing, size, age, sex ratio, and any other traits identified as important for long term fitness. Returning adults used as broodstock by a hatchery program must continually incorporate natural-origin fish over the duration of a program to reduce the likelihood for divergence of the hatchery population from the wild counterparts. Spawning protocols, including collection of broodstock proportionally across the breadth of the natural return, randomizing matings with respect to size and phenotypic traits, application of at least 1:1 male-female mating schemes (Kapusinski and Miller 1993), and avoidance of intentional selection for any life history or morphological trait, should be applied to increase the likelihood that hatchery broodstocks are representative of wild stock diversity. Minimum broodstock collection objectives should be set to allow for the spawning of the number of adults needed to minimize loss of some alleles and the fixation of others (Kapusinski and Miller 1993). Hatchery methods that mimic the natural environment to the extent feasible should be applied (e.g. use of substrate during incubation and exposure to ambient river water temperature regimes during rearing).

2. BETWEEN POPULATION VARIABILITY: Loss of between (or “among”) population variability or diversity is the reduction in differences in quantity, variety, and combinations of alleles among populations (Busack and Currens

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1995). Loss of genetic variability among populations may occur through replacement of extent, locally adapted wild salmonid populations by a smaller number of relatively homogenous populations as a result of a hatchery supplementation program, or inter-breeding with straying hatchery fish. This replacement may occur when hatchery-origin fish mate with wild fish that are unrelated or distantly related, resulting in gene flow that is in excess of natural levels. The potential result of this infusion of introduced alleles is reduction in the frequency of adaptive alleles and co-adapted allele complexes, leading to short or long term reduction in performance of the wild fish (outbreeding depression) (Busack and Currens 1995). Consolidation and possible homogenization of populations within an ESU or between regions may lead to decreased fitness, limiting the potential of a species or group of populations to adapt to new environmental conditions. At the individual population level, loss of genetic uniqueness with a concurrent reduction in performance of the fish is of concern (Busack and Currens 1995).

To reduce the risk of loss of between population variability, hatchery programs must avoid transfer of eggs and fish from different populations between hatcheries. Hatchery programs should propagate and release only indigenous fish populations. Release of hatchery fish into watersheds outside the original distribution of the introduced fish may result in gene flow above natural levels, and must be avoided. As an additional measure, hatchery fish stray rates between ESUs must be managed such that less than 5% of a naturally spawning population consists of hatchery fish. Within an ESU, hatchery stray rates must be managed such that not more than 5% - 30% of the naturally spawning population consists of hatchery fish originating from within the ESU. To minimize straying, hatchery populations must be acclimated to the watershed where the fish are planted to ensure that propagated fish retain a high fidelity to the targeted stream. Local adaptation must be fostered by using returning spawners rather than the transferred donor population as broodstock for restoration programs. In addition, natural populations within an ESU, representing significant proportions of the existing total abundance and diversity of the ESU, should be maintained without hatchery intervention. Most, if not all, anadromous salmonids produced in hatchery programs must be marked to allow for monitoring and evaluation of straying and natural spawning contribution of adult returns.

- F. **HARVEST EFFECTS:** Depending on the characteristics of an adopted fishery regime, the commercial or recreational pursuit of hatchery fish in mixed-stock or mixed-

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population fisheries can lead to harvest of naturally produced fish at levels in excess of those compatible with their survival and recovery. Hatchery fish must not be produced in numbers and/or locations such that when, as adults, they migrate through adopted fisheries regimes, leading to harvest of listed ESUs and their component populations at excessive rates that impair their survival and recovery. Hatchery production and harvest management must together be compatible with species survival and recovery.

- G. **MASKING EFFECTS:** The return and natural spawning of F1 hatchery fish, desired or not, can mask the status of the listed, naturally-produced population. This situation can also mask the proper functioning of the critical, freshwater habitat and its condition required to sustain viable naturally produced fish populations. Artificially produced fish must therefore be sufficiently marked, internally or externally, to allow for the ready distinction of hatchery vs naturally produced fish for stock assessment purposes, including recovery on the spawning grounds. Such marking is especially essential for those hatchery populations for which straying and naturally spawning in sufficient numbers (see above) is known or suspected.

Artificially produced fish populations must also be sufficiently marked, when necessary, to allow their distinction from naturally produced fish in order to manage broodstock collection and mating, and quantify any take of listed fish during broodstock collection.

- H **AREA OF EFFECTS - TRIBUTARY, MAINSTEM REARING, MIGRATION CORRIDOR, ESTUARY AND NEAR OCEAN:** The action area considered for “jeopardy” determinations will include critical habitat identified for each listed species by NMFS in Federal Register Notices (FRN), freshwater migration corridors critical for the listed species, and estuarine and nearshore ocean areas that are important for the early marine survival of the listed species. In some cases, FRNs announcing critical habitat designations will include the migration corridor and nearshore marine areas. Oceanic areas beyond nearshore marine areas will not be considered in “jeopardy” evaluations. The limited information available concerning effects to listed salmon resulting from changes in the historic ocean carrying capacity is insufficient to determine definitive impacts from hatchery fish releases. The effects of hatchery fish production on listed salmon and steelhead in the ocean would be speculative, since hatchery fish intermingle at the point of ocean entry with wild and hatchery anadromous salmonids from many regions.

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EVALUATION AND ASSESSMENT PRINCIPLES

1. When assessing the potential effects of hatchery actions on the survival and recovery of listed species, it may be appropriate to give greater consideration, or conversely allow greater risks, to different populations within a given ESU, based on their origin and importance to the ESU. Generally, the greater protection should be afforded those native populations that persist in their original habitats. Second priority for risk aversion should be given to transplanted populations originating from other watersheds within the ESU that have replaced (largely or totally) the native population, in habitats that have historically sustained natural chinook populations. Thirdly, any populations comprised of natural spawning “hatchery strays”, in habitats that have not historically sustained natural chinook populations, may require minimal protection from potential hatchery effects. Finally, populations of fish transplanted from outside the ESU do not require ESA protections and should be considered for replacement from an appropriate population originating from within the ESU, particularly if the habitat in question is essential to the species viability and recovery.
2. Hatchery effects need to allow for the rebuilding of natural origin recruit numbers (and self-sustainability) in those populations needed for survival and recovery of the ESU.
3. Hatchery programs not isolated from a local, natural population must originate from that local population.
4. Monitoring and Evaluation Plans are essential to ensure risks are minimized and within the level of take authorized.
5. See attached flow diagram.

[JEOP100.p12]